New Scientist

WEEKLY 23 September 2023

THERAPY SPEAK
How the overuse of mental health terms can actually cause harm

CIPHER SOLUTIONS
The new tools helping to decode secret messages from history

IT'S STILL NOT ALIENS
NASA's final UFO report finds no signs of extraterrestrials

DARK STAR

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NS Live

STEAM mode on

Hear mathematical prodigy Anne-Marie Imafidon share life advice on how to carve a future in science, technology, engineering, arts and maths (STEAM). On 9 October, at New Scientist Live's Schools' Day, Imafidon will offer insights into what STEAM is, why technology matters and why today's teenagers have more opportunities than most to make a real difference in their lives.

newscientist.com/nslmag

Tour

Tasmania's flora, fauna and geology: Australia

Tasmania boasts golden beaches, misty mountaintops and lonely patches of wilderness. Join biologist and conservationist Martin Cohen in seeking out Tasmanian devils, platypuses and fairy penguins. Wander among ancient geology and discover the island's Indigenous culture dating back more than 35,000 years. This 12-day tour begins on 20 February 2024 and tickets cost £4595.

newscientist.com/tours

Podcast

Weekly

The team discuss the annual Ig Nobel prizes for the silliest (yet still serious) scientific discoveries and talk about unusual black holes that have been spotted by the James Webb Space Telescope. Plus, an update on covid-19 boosters and the mysterious case of why male frogs make mating mistakes.

newscientist.com/nspod

AUSTRALIAN ASSOCIATED PRESS/ALAMY

Corpse flower An unpredictable plant that emits a foul odour

NASA, ESA, AND J. DEPASQUALE (STSCI)

Weird objects Ancient black holes are unexpectedly massive

Video

Brain implants become reality

Synchron is commercialising a brain implant that lets people control touchscreen devices with brain signals. Rather than using invasive, open-skull surgery, the company inserts a special electrode called a stentrode into a blood vessel near the brain's motor cortex, the region that controls muscle movements.

youtube.com/newscientist

Newsletter

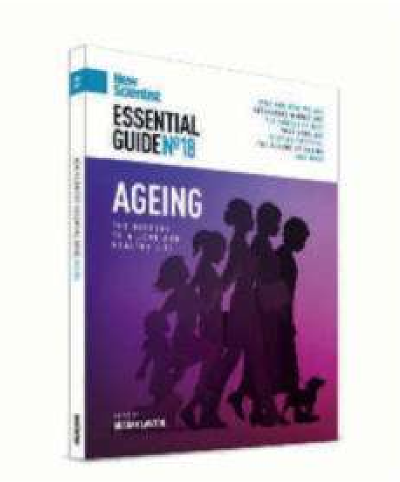
Wild Wild Life

The corpse flower rarely blooms. When it does, a horrendous odour – similar to rotting flesh – is released and wafts more than a kilometre downwind. Chelsea Whyte reveals the strange history of the corpse flower and examines why it is so hard to grow, and even harder to predict when it will bloom.

newscientist.com/ wild-wild-life

Podcast

> **"In the heat of the moment, male frogs sometimes grab the wrong warm body"**



Essential guide

What drives the ageing process? What can science tell us about the stages of life? And how can we use the latest research to live healthily into old age? This *New Scientist Essential Guide* offers some fresh insight. Available to download in the *New Scientist* app or to purchase in print from our shop.

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The limits of awareness

When it comes to mental health, recognising the problem isn't enough

IT'S good to talk, the saying goes, and we are talking about mental health more than ever. This is generally seen as positive: raising awareness breaks down stigma long associated with conditions like anxiety and depression and empowers people to seek help. But we should be asking whether this trend is entirely a force for good – and confronting the possibility that it might, in some cases, be counterproductive.

The most obvious shift is that language once the preserve of psychotherapists has been co-opted into common parlance. Trauma, boundaries, triggering and so on: "therapy speak" is now ubiquitous. This can sometimes help identify problems that might otherwise go unaddressed.

But some psychologists are concerned about concept creep (see page 33). The misuse of terms whose meanings are being lost might have unintended consequences. It can encourage people to think that all negative thoughts or feelings indicate a mental health condition, for instance. If we see harm everywhere, we may be more likely to feel vulnerable or victimised.

> "Language that was once the preserve of psychotherapists has been co-opted"

Then there are the many initiatives to tackle mental health problems popping up in schools and workplaces in several countries. Courses in mental health "first aid" training teach people to spot signs of various conditions in others and offer support where required. This seems like a good idea, and the schemes are clearly well-intentioned. But when researchers looked for evidence that one of the most widely adopted courses improves mental health, judged by the extent to which it reduces negative symptoms, they found precious little solid evidence (see page 11).

This isn't to discount the myriad upsides of rising awareness of mental ill health. Many people experience genuine trauma and triggers, and benefit from growing recognition of such problems. Nor is it to minimise the issue: rates of people seeking mental health treatment have been rising for years, particularly in teenagers and young adults. But if we are serious about improving mental health, we shouldn't shy away from difficult conversations about what really works and what doesn't. ▮

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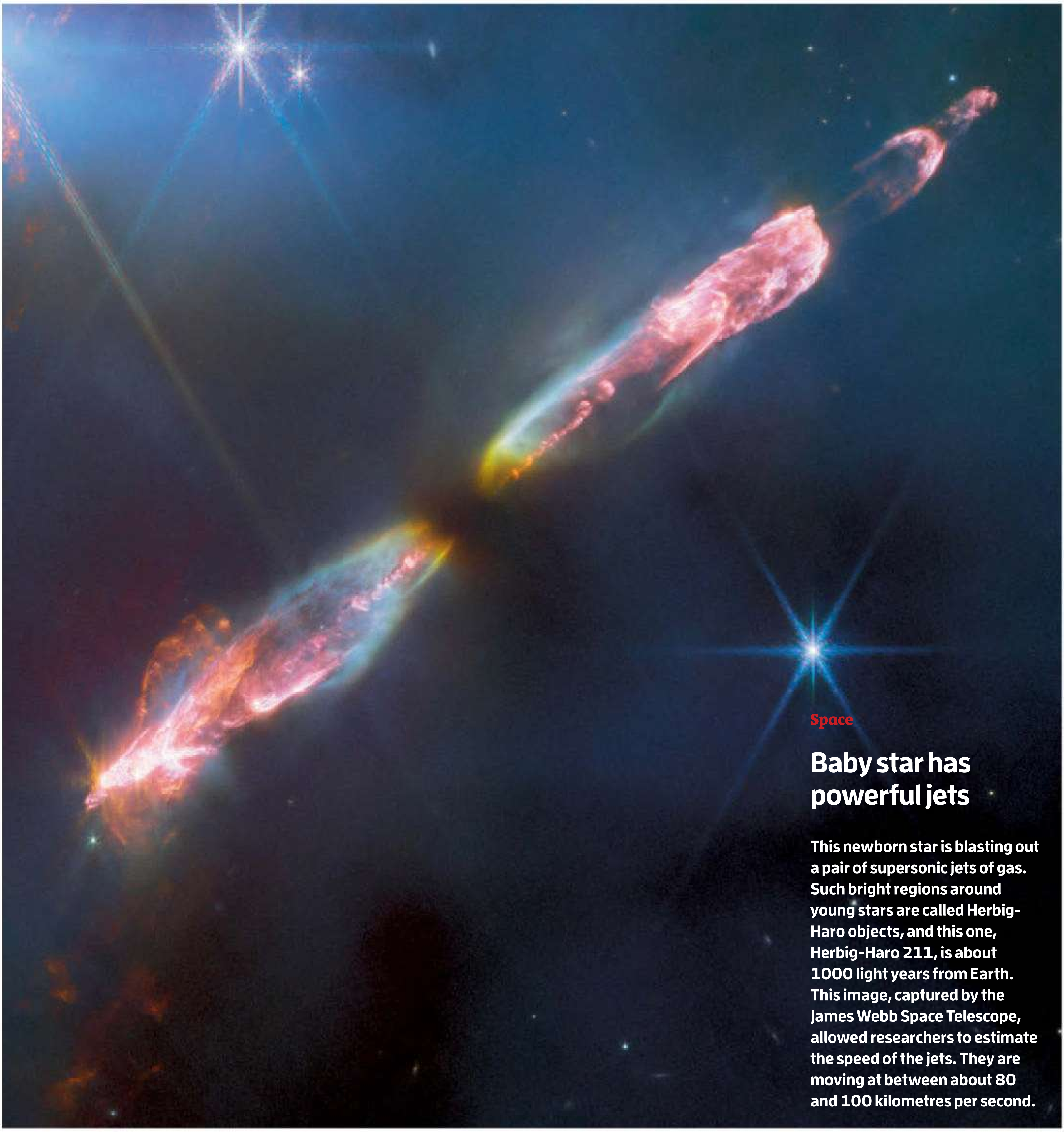


NASA/ESA/CSA/JWST

Space

Baby star has powerful jets

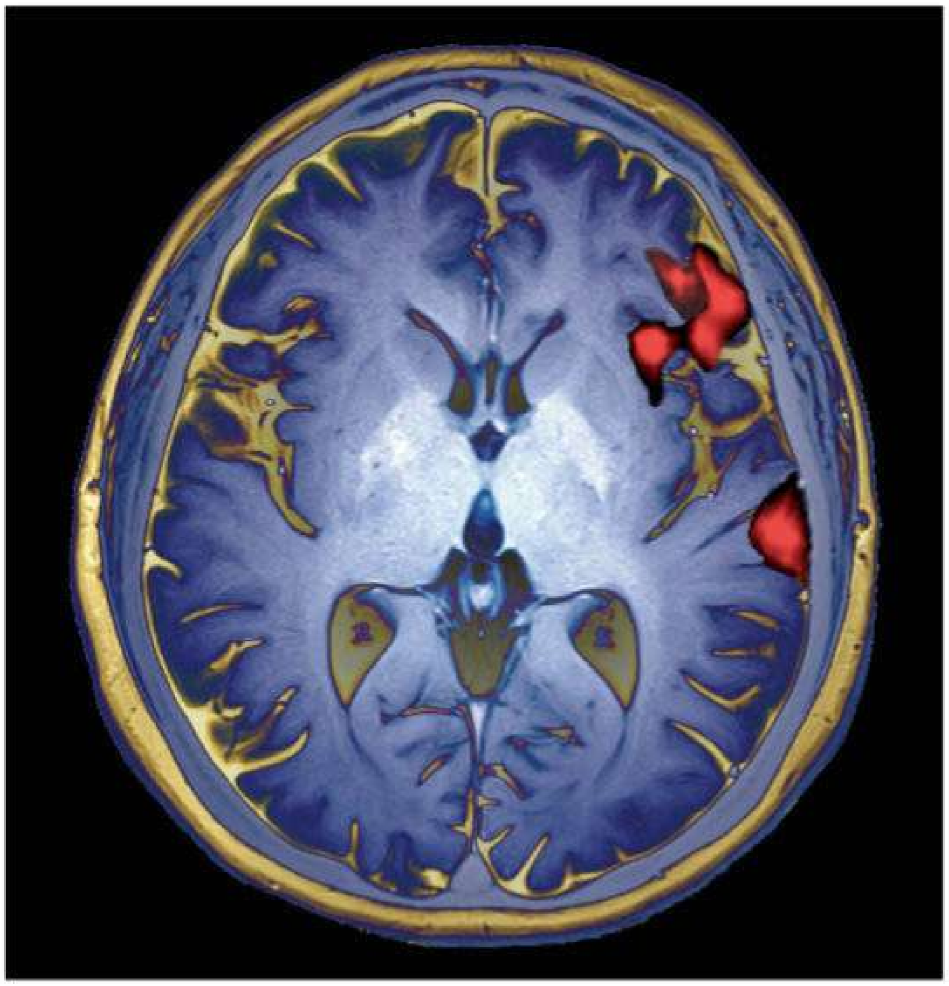
This newborn star is blasting out a pair of supersonic jets of gas. Such bright regions around young stars are called Herbig-Haro objects, and this one, Herbig-Haro 211, is about 1000 light years from Earth. This image, captured by the James Webb Space Telescope, allowed researchers to estimate the speed of the jets. They are moving at between about 80 and 100 kilometres per second.

Building a brain in a dish
Hear Selina Wray on the promise of stem cells on 8 October
newscientist.com/nslmag

Neuroscience

Whole brain may be used in language

Brain regions identified as language centres may actually be hubs that coordinate the processing of language across the brain, finds **Michael Marshall**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When we speak, brain activity spikes (red) in regions near Broca's area

WE HAVE misunderstood how the brain processes language, says a controversial new analysis. The brain regions that have been identified as specialised language processing centres are actually hubs that coordinate the processing of language across multiple brain regions, argue Jeremy I. Skipper at University College London and his colleagues.

Their idea runs counter to most models of language in the brain and has been met with scepticism.

Since the late 1800s, there has been growing evidence that specific brain areas process language. For example, Broca's area in the frontal cortex is thought to be involved in speech. People with damage to this area understand what is said to them, but can struggle to speak. Brain imaging studies consistently show activity in this and other areas when performing language tasks.

Skipper doesn't dispute that regions like Broca's area are involved in language processing, but he thinks much of the rest of the brain also plays a role. "There's a ton of processes that go into language," he says. "It's the most complicated thing we do as human beings."

To demonstrate this, he and his colleagues conducted a two-part study. In the first part, they reanalysed data from existing meta-analyses of previous studies of brain imaging data. They confirmed that research looking at language processing showed activation was localised to regions like Broca's area.

However, when they looked at more specific forms of language processing, for example of nouns versus verbs, they saw many more brain regions coming online.

Skipper argues that this is because different language tasks use different parts of the brain, but brain imaging studies work by taking averages across multiple tasks. As a result, a region that is activated by the word "elephant" but not "chicken" wouldn't show up in the averages, even though it is actually involved.

"Those language regions that survive, when you average, are actually connectivity hubs," says Skipper. "Those are the regions that coordinate lots of other regions in the brain."

> **"Any given 'language region' is talking to more than 40 per cent of the rest of the brain at any moment"**

The researchers also scanned people's brains as they watched movies. The films had been annotated so the team knew when characters were speaking and what they were saying, so they could see changes in brain activity as people processed language. Again, activation wasn't confined to regions like Broca's area, but encompassed up to 67 per cent of the brain (bioRxiv, doi.org/ktps).

Evelina Fedorenko at the Massachusetts Institute of Technology disputes the work's conclusions. She has studied a network of brain regions known as the multiple demand network, which she says is sometimes activated during language processing, but that isn't specific to language. Instead, she says these areas "are active during diverse demanding tasks", and that is what the team's meta-analysis picked up.

Skipper, however, says he and his colleagues don't believe that such a fixed multiple demand network could exist anatomically. Rather, they believe that nearly any part of the brain can kick in as needed.

It is difficult to reconcile ideas of the whole brain being involved in language with evidence from brain lesions in people who have had a stroke, says Kristina Simonyan at Harvard Medical School. "One lesion in one particular region of the brain and people lose their ability to speak."

She does think there is some kind of distributed network, though. While regions like Broca's area are crucial for language, many other parts of the brain are believed to be involved, she says.

For example, Simonyan and her colleagues have used brain imaging to find six distinct communities of neurons involved in speech control, including in brain structures like the putamen and thalamus that are far removed from regions like Broca's area. Simonyan has also been involved in work showing that a different set of regions is activated depending on whether people are saying meaningful sentences or meaningless syllables. For this reason, she describes the new study as "confirmatory" rather than "life-changing".

For Fedorenko, the key point about regions like Broca's area is that they respond selectively to language. She says other brain regions can be involved, but those regions aren't language specific.

But Skipper doesn't think that regions like Broca's area are only selective for language. Most brain regions participate in many tasks, he says, something called neural reuse. "Any given 'language region' is talking to more than 40 per cent of the rest of the brain at any given moment, which means, by definition, that those other regions are language specific in those moments," says Skipper. ▮

Zoology

Tadpoles change colour to blend in with surroundings

Jason Arunn Murugesu

THE skin colour of tadpoles can change to better match their environment, making them harder for predators to spot.

Christoph Liedtke at the Doñana Biological Station in Seville, Spain, and his colleagues studied the tadpoles of western spadefoot toads (*Pelobates cultripes*). They grew five tadpoles for 40 days in each of 10 trays that were painted different colours: black, white, red, green, blue and five different shades of grey.

The tadpoles changed colour to match their background in the black, white and grey trays, but not the red, green and blue trays. This suggests they change their colour based on the brightness of their backgrounds and not hue or saturation, says Liedtke.

If a tadpole was moved from the darkest tray to the lightest, or vice versa, it would change colour again.

"You can see both darkening and lightening with your eyes in 24 hours," says Liedtke. It took a week for tadpoles to reach their darkest colouration, but three to four weeks to match the lightest tray, he says (*Scientific Reports*, doi.org/ktqc).

Tadpoles change colour in a different way to animals like chameleons. Chameleons do it by rearranging how pigments are distributed in a cell, which can occur very quickly. In tadpoles, changing colour involves the synthesis or degradation of pigments. Liedtke suspects it is quicker to produce the pigment required for darkening than it is to break down that same pigment, which explains why they are slower to go from dark to light.

Tadpoles probably need this camouflage ability to hide from predators because a pond can go from having very little vegetation in the early spring to far more vegetation later in the year, which makes the water darker, says Liedtke. ▮

Alien life

NASA's UFO task force finds no evidence for alien craft

Leah Crane

THE task force at NASA investigating UFOs and other unexplained objects in the sky has released its final report. It found no sign of any alien craft, just benign terrestrial phenomena such as balloons and weather events.

The team was formed in 2022 with the task of gathering and analysing all the available data on unidentified anomalous phenomena (UAPs), and developing a path forward for NASA to continue studying them. Now it has done so. The final results were released in a report and press conference on 14 September.

"We find no evidence that UAPs are extraterrestrial in origin," said team lead David Spergel at Princeton University during the press conference. "Most events are explainable as planes, balloons, drones, weather phenomena and instrument features."

Some of the events remain unexplained, but that is mostly due to the limited amount and low quality of the data on most UAPs. Military data is largely classified because the US government keeps the nature of the instruments collecting it secret, and civilian data is often just blurry mobile phone photos and vague recollections.

"While there are numerous eyewitness accounts and visuals associated with UAPs, they're not consistent accounts, they're not detailed and they're not curated observations that can be used to make definitive scientific conclusions about the nature and the origin of UAPs," said Nicola Fox, the head of NASA's Science Mission Directorate, in the press conference.

One of the recommendations in the final report is that NASA begins a programme to use scientific instruments for UAP detection, as well as enhancing its communication and data gathering within and beyond the government. Within NASA, the hope is that this will help reduce the stigma around reporting apparent UFO sightings – often seen as unscientific and unserious – so we can better characterise strange phenomena in the sky.

Part of that is a focus on transparency, said NASA administrator Bill Nelson in the press event. "There's so much concern that there's something locked up, classified, and that the American government is not being open. Well, we are the American government and we are open and we're going to be open about this – but we don't know what these UAPs are."

"We are the American government and we are open, but we don't know what these UAPs are"

NASA has appointed a director of UAP research "to centralize communications and leverage NASA's extensive resources and expertise to actively engage in the whole-of-government UAP initiative", according to the report. During the press conference, NASA officials declined to name this director and didn't share information on budgetary allocations for UAP studies.

For now, there is no evidence of alien technology in our skies. The overall conclusion of the UAP team's study is that if we want to find any evidence of that, we need to observe and study objects in the skies much more rigorously. "In a process like this… you need to know what typical, regular things look like under all conditions," said Spergel. "You need to know what balloons look like when pilots see them under unusual conditions."

Otherwise, it may be impossible to tell apart a weird balloon and an alien craft. ▮

A meeting of NASA's task force studying unidentified phenomena

NASA/JOEL KOWSKY

New Scientist Live
Launching the UK to space
See Melissa Quinn from Slingshot Aerospace on 8 October
newscientist.com/nslmag

Space

Student rocket set for space launch

Imperial College London project will try to send its rocket to an altitude of 105 kilometres

Matthew Sparkes

A GROUP of students is aiming to become the first non-government, non-commercial team to send a reusable rocket to space. The team's Aurora rocket, set to launch from California this month, is designed to reach a top speed of Mach 5.2 and break through Earth's atmosphere.

The Karman Space Programme (KSP) was founded by students at Imperial College London two years ago, with the aim of breaking through the Kármán line, the 100 kilometre altitude that is widely recognised as the edge of space.

To achieve this, they designed and built a 540-kilogram rocket that stands 12 metres tall and is 50 centimetres in diameter – although it will be assembled for the first time at the launch site.

The craft consists of two separate stages, each with its own engine fuelled by liquid oxygen and ethanol. Aurora's first stage engine has an estimated 40,000 newtons of thrust, and the group says it is the most powerful non-governmental, non-commercial rocket engine ever built.

Each stage will fire for just over 20 seconds, and the rocket will be travelling at 5522 kilometres an hour at its peak speed. About 100 seconds after launch, it will reach its highest point and then should begin falling back to Earth for a soft landing by parachute.

ENOCH WONG/KARMAN SPACE PROGRAMME

The Karman Space Programme team and prototype Vega rocket

To ensure the rocket passes the Kármán line, the team is aiming for an altitude of 105 kilometres. If successful, it will be the second student-led team to reach space, and the first to do it with a reusable rocket.

KSP's chairman, Shapol M., says the first student space shot – by a team at the University of Southern California in 2019 – was impressive, but that the rocket was single-use and had solid motors. It also isn't certain it reached space because of the margin of error in measuring its altitude.

Shapol says the KSP mission will use multi-stage liquid engines like commercial launchers, recover all sections of the rocket and could, in theory, be turned around for a second launch within 24 hours.

The team is planning to launch Aurora from a site in the Mojave desert in California on 24 September. "Launching outside the UK is a huge pain, but there isn't a place right now to launch up to these altitudes in the UK. It's a real shame," says Shapol.

About 100 students have helped on the project, using AI to run simulations and metal 3D printing to fabricate parts. Some 25 have since graduated, but the rest are still working on the mission.

Imperial has allowed the rocket to be built on its campus, but isn't funding the project, so students have had to source corporate sponsors. The total cost was £150,000, says Shapol. "It really is the team that's powering this more than propellants," he says.

Shapol says it is hard to predict what will happen at launch, but preparations have included tests of many components. The team's previous rockets include Vega (pictured), powered by the same engine as Aurora's second stage. "We've tried to fail as much as possible before, so that we don't fail on the big one," says Shapol. ▮

Health

Enzyme test may let doctors diagnose Parkinson's earlier

HIGH levels of a certain enzyme in spinal cord fluid could be a sign of Parkinson's disease – potentially enabling the condition to be diagnosed earlier.

Parkinsonian disorders are neurodegenerative conditions that typically affect movement. They include Parkinson's disease and a related condition called dementia with Lewy bodies (DLB).

These conditions are usually only diagnosed once symptoms, such as slow movement or stiff limbs, appear. "It's quite difficult, even for experienced clinicians, to diagnose individuals with a Parkinsonian disorder, especially in its early stages," says Oskar Hansson at Lund University in Sweden.

To see if there might be a way to make a diagnosis earlier, Hansson and his colleagues carried out tests on 81 people with Parkinson's disease or DLB and 347 people who had no symptoms of the conditions.

They collected samples of each person's cerebrospinal fluid, which bathes the brain and spinal cord. In participants with Parkinson's disease or DLB, the fluid contained higher levels of DOPA decarboxylase – an enzyme involved in the production of dopamine – than in people without these conditions.

Among those who weren't diagnosed with a Parkinsonian disorder, 35 had raised levels of DOPA decarboxylase. After three years of monitoring, 12 of this group had developed Parkinson's or DLB. The researchers found the same link between levels of the enzyme and Parkinsonian disorders in another cohort of 94 people and in samples of blood plasma from a further 282 people (*Nature Aging*, doi.org/ktqm).

"It's quite difficult, even for experienced clinicians, to diagnose individuals with a Parkinsonian disorder"

If the finding is confirmed by larger studies, measuring DOPA decarboxylase could help diagnose Parkinsonian disorders earlier, says Hansson, although there is still no known way to prevent them. But identifying such biomarkers could also help us identify possible methods for treatment, he says. ▮

Chen Ly

Health

Anti-ageing drugs could make more organs viable for transplants

Moheb Costandi

DRUGS that clear away worn-out cells may improve the success of transplanted organs from older donors, according to research in mice.

As we get older, some cells stop dividing, but linger instead of dying off. These so-called senescent cells accumulate in our organs, releasing chemicals that can trigger inflammation and promote disease.

When an organ from an older donor is transplanted into a younger person, senescent cells in the transplanted organ can activate senescence in the recipient's own cells. This "transfer" of ageing can worsen the outcome of the transplant or even elicit an immune response that results in rejection of the donated organ.

Stefan Tullius at Harvard Medical School and his colleagues have succeeded in stopping this transfer process in mice using senolytics, a new class of drugs that selectively clear away senescent cells. They presented their work at the European Society for Organ Transplantation Congress in Athens, Greece, on 18 September.

The team first transplanted hearts from older and younger mice into young recipients. As expected, mice that received hearts from older animals had more senescent cells in their lymph nodes, muscles and organs than those that got hearts from younger animals had.

Mice that received hearts from older animals also exhibited accelerated cognitive and physical decline. However, treating the older mice with the senolytic drugs dasatinib and quercetin before their organs were harvested significantly reduced the number of senescent cells found in the recipients after transplantation.

STURTI/GETTY IMAGES

More human organs are needed for transplant than are available

The animals that received older hearts treated with the drugs also matched recipients of younger hearts in their cognitive performance and physical fitness.

"This is a promising approach with many potential implications," says Jesús Gil at Imperial College London, although there are questions about how the findings will translate to humans. "[Human] donors might be dead, so, in practical terms, you might need to treat the organ itself before transplantation or the recipient, which might not be possible."

21

This many people die daily in Europe waiting for a transplant

The number of people needing organ transplants is increasing, but organs are in short supply. Recent data shows that 21 people die every day on average across Europe waiting for a transplant.

The age of the donor is a crucial factor determining the success of transplants and so, despite the urgent need, organs from older donors are often turned down.

Gil says this use of senolytics could offer "a potentially very useful approach that could impact transplant recipients, and potentially increase the pool of organs that can be transplanted that, in the past, were rejected".

The researchers are now planning to investigate if their findings are applicable to humans. "We will delve deeper into the mechanisms underpinning our current findings, with a particular focus on the potential role of senolytics in preventing the transfer of senescence in humans," says Tullius. He adds that the research "may not only help us to improve outcomes, but also make more organs available for transplantation". ■

Geology

Rare pink diamonds appeared after geological break-up

Alice Klein

AUSTRALIA'S pink diamonds were brought to the surface from deep underground about 1.3 billion years ago when the former supercontinent Nuna broke up.

Pink diamonds are extremely rare and prized. More than 90 per cent of those found so far have come from the Argyle Diamond Mine in Kimberley, Western Australia.

Like other diamonds, Argyle pink diamonds formed at least 150 kilometres underground in Earth's ancient past and started out colourless. Then, about 1.85 billion years ago, they are believed to have turned pink when two former continents – which now form northern and western sections of Australia – smashed together to become part of a supercontinent called Nuna that once incorporated 90 per cent of Earth's landmass.

The collision deformed the crystal structures of diamonds caught in the middle and caused them to reflect light differently, becoming pink, says Hugo Olierook at Curtin University in Western Australia.

Olierook and his colleagues have now used radiometric methods to date diamond-containing rocks from the Argyle Diamond Mine and say the diamonds settled at the surface between 1.31 and 1.25 billion years ago (*Nature Communications*, DOI: 10.1038/s41467-023-40904-8). This coincides with when Nuna started to break into smaller continents, says Olierook.

The northern and western sections of Australia held together at this time, but they were stretched apart enough for diamond-containing magma to well up between the former continents.

Most diamonds have been found in the middle of ancient continents, pushed up by volcanic activity. The origin and location of the Argyle deposit hints that the gems may also be found at the edges of these landmasses, says Olierook. ■

Environment

Humans are using too many plants

We are using 26 per cent of the biomass produced by land plants, which is more than is safe

Michael Le Page

WE ARE now consuming over a quarter of the biomass produced each year by plants on land, leaving too little for wildlife and putting at risk the biosphere on which all life on Earth depends. To keep the planet in a suitable state for civilisation, we should be using no more than a tenth of plant biomass, say researchers.

This means that plans to tackle climate change by using even more biomass, for instance by turning it into fuel for aeroplanes, will damage the planet in other ways, says Katherine Richardson at the University of Copenhagen in Denmark, such as by boosting deforestation and species loss.

"That we're already using too much biomass, of course, is a blow to those who want to use biomass for energy and for capturing CO_2," she says. "You're just not going to solve the climate problem if you don't also respect the deforestation problem we have."

Richardson is part of a team that has been exploring what we need to do to keep Earth in a state similar to that during the 10,000 years leading up to the industrial revolution, to ensure that people can thrive. In 2009, the team proposed that there are nine main limits, or planetary boundaries, that shouldn't be breached if we want to prevent drastic changes that endanger us as well as nature.

"We're not only affecting the climate, we're also affecting the water, the biodiversity, ocean acidification, the ozone layer and so on," says Richardson. "How far is it safe to go? You need some kind of guard rails."

Besides the climate, maintaining the biosphere – the planet's life-support system – is the most important of these boundaries, says Richardson.

Back in 2009, it was clear that the loss of genetic diversity had already reached dangerous levels, but the researchers were unable to find a good measure of how the functioning of the biosphere has been affected.

They have now measured it in terms of how much of the biomass produced by photosynthesis is being used by humans, or is no longer being created, relative to pre-industrial levels. Plant biomass is the basis of food chains, so if we take it, the life that depends on it dies out.

The study estimates that plants on land produced 56 gigatonnes of biomass a year, as measured by its carbon content, in pre-industrial times, and that through farming, logging, the grazing of domestic animals and so on, people now take 17 gigatonnes per year, or about 30 per cent of pre-industrial levels. Today, plants produce an estimated 66 gigatonnes of biomass a year due to higher carbon dioxide levels, and would produce more if not for land degradation, so our current consumption is about 26 per cent (*Science Advances*, doi.org/gsqg7z).

Richardson and her colleagues propose that a safe limit for this exploitation by humans would be 10 per cent of pre-industrial plant biomass, and that anything over 20 per cent is high risk.

Logged forest in the Great Bear Rainforest, British Columbia, Canada

JOHN ZADA/ALAMY

Technology

Facebook change to stop misinformation on vaccines backfires

ATTEMPTS by Facebook to remove misinformation about covid-19 vaccines from its platform instead made anti-vaccine content more extreme, say researchers.

David Broniatowski at the George Washington University in Washington DC and his team looked at engagement with more than 200,000 posts on Facebook pages and groups between 15 November 2019 and 28 February 2022. Within that period, Facebook made major changes to its approach to clamping down on content that shared incorrect information about vaccinations.

The researchers analysed the number of posts before and after the first of those changes – the removal of a major anti-vaccine page in November 2020 – as well as the level of engagement with those posts, measured by counting the shares, comments, likes and other reactions to the content.

"Facebook did remove a lot of content and several accounts," says Broniatowksi, but this didn't really achieve the stated aim. The volume of content on anti-vaccine pages decreased to 32 per cent of what was happening before the change, and the amount on pro-vaccine pages didn't change much, but people who avoided bans began posting more reactionary, aggressive misinformation.

"The stuff that remained became, on average, more misinformed, not less," says Broniatowksi. The posts included more links to websites known to be purveyors of misinformation, as well as a higher proportion of topics known to be common areas of misinformation.

"The stuff that remained became, on average, more misinformed. It's as if the policy had no effect"

Anti-vaccine posts also saw a 33 per cent higher level of engagement than would have been expected before the policy changes (*Science Advances*, doi.org/gsqrds). "It's as if the policy had no effect," says Broniatowski.

Meta, the parent company of Facebook, didn't respond to requests to comment.

Chris Stokel-Walker

Animal behaviour

Mosquitoes dodge fly swatters by surfing a wave of air

Jake Buehler

IT IS surprisingly difficult to swat mosquitoes and we may now understanded why. They sense the airflow created by an incoming strike and surf the air pressure waves to safety.

Anopheles mosquitoes can be difficult to swat while in flight

BOYD NORTON/ALAMY

Antoine Cribellier at Wageningen University in the Netherlands and his colleagues used infrared cameras to track individual *Anopheles coluzzii* mosquitoes as they flew under both twilight and dark conditions in the lab. They then used a mechanical swatter to strike at each insect's predicted path.

When the researchers used high-speed cameras to film any escapes and ran analyses on what happened, they discovered that the mosquitoes make sharp turns away from the swatter as it approaches, even in darkness. Most of the aerodynamic force needed to escape the swatter comes from each mosquito's wingbeats. But by reorientating themselves, the insects get as much as 41 per cent of the required escape force from the air pressure wave generated by the swatter (bioRxiv, doi.org/ktn5).

Much like surfers swimming in the same direction as a wave before they ride it, "they are letting themselves be pushed away by the swatter, but they are also contributing actively to their escape", says Cribellier.

The mosquitoes may position themselves to catch the wave by sensing small perturbations in the air with their antennae, says Sanjay Sane at the Tata Institute of Fundamental Research in India. ▮

Analysis **Medical evidence**

Mental health 'first aid' questioned

There is no good evidence that a training scheme on how to support people with conditions like depression actually works, finds **Clare Wilson**

A WIDELY used mental health "first aid" course has no good evidence showing that it has any medical benefits, nor has it been carefully investigated to see whether it could cause harm, a major review of the research has found.

The idea behind the Mental Health First Aid programme, initially developed in 2000, is to train members of the public to support people with conditions such as depression and anxiety and advise them how to seek medical help. It is now common for workplaces or community groups in many countries to offer the training, typically providing it over four half-days, either face-to-face or online.

Participants learn how to spot signs of mental health problems in others; how they can offer basic support, such as non-judgemental listening; and how to steer those affected to professional help. A modified version is also offered to teenagers in some schools.

Many studies have found that people who do the training have improved knowledge, feel more confident about offering support and believe that it reduces stigma about mental health conditions. Yet it is unclear whether the courses offer more concrete benefits, such as reducing symptoms of depression or anxiety.

An analysis last month by the Cochrane Collaboration, an independent medical evidence review body, found there have been 21 randomised trials where Mental Health First Aid training was compared with either doing nothing or offering a control intervention, such as a physical first aid course. They included more than 22,500 people and were in settings such as workplaces, schools and colleges across a variety of countries.

Only five of the trials looked at whether the courses boosted mental health, and these found that any differences between the groups were so small that they could have arisen by chance. There were also problems with the research methods, such as these five studies not including enough people to draw firm conclusions (Cochrane Database of Systematic Reviews, doi.org/ktn6).

"It is striking that a training programme that has been so widely adopted is not better supported by solid evidence that it is effective in improving mental health. This seems to me to be the key test of how well it works," said Rachel Richardson, who helped carry out the review, in a blog post.

None of the 21 trials systematically gathered evidence about whether the course could do any harm. "It is not difficult to imagine that there might be disadvantages," said Richardson. "Would first-aiders 'take on' too much – would they feel overly responsible?"

"It is striking that training that has been so widely adopted is not better supported by evidence"

Anthony Jorm at the University of Melbourne in Australia, who developed the programme, says that while randomised trials are the best way of assessing medicines, it can be hard to carry them out for psychological interventions. "Participants have to agree to random assignment and may not get the intervention they want," he says. "It can be challenging to recruit participants."

Jack Andrews at the University of New South Wales in Sydney, says the findings will generate concerns for mental health practitioners. "We need to tread carefully when we are running ahead to widely implement initiatives when the evidence base is weak." ▮

Mental health support is increasingly offered in office environments

FIORDALISO/MOMENT RF/GETTY IMAGES

See page 33 to read about "The dangers of therapy speak"

New Scientist Live

Are psychedelics the future of mental health?

See neuroscientist Jonathan Iliff on 7 October

newscientist.com/nslmag

Animal behaviour

Frogs have attempted sex with other species for millions of years

Jake Buehler

BUITEN-BEELD/ALAMY

This green male pool frog is trying to mate with a common toad

MATING frogs may have been occasionally getting it wrong for hundreds of millions of years. We know that males today sometimes select an inappropriate partner in the breeding season – a frog from a different species, a turtle, a fish or even an inanimate object. Now, there is evidence that these mistakes could be an ancient feature of frog reproduction, arising early in the amphibians' evolution.

Frog mating is often hard to miss. In most species, it involves a process called amplexus, in which males grip onto a female tightly for hours or days at a time until the eggs are fertilised. But there are plenty of records of male frogs grappling an unpromising target, such as a frog from a different species or a dead individual. One explanation is that such mistakes are more likely to happen in species that breed in large numbers with a low ratio of females to males, and where multiple species occupy the same breeding pond.

"For a male facing huge competition with rivals to reproduce, it would be advantageous for males to arbitrarily be attracted to – and thus clasp – any female-looking object in order to increase mating probabilities," says François Brischoux at La Rochelle University in France.

But misdirected amplexus is also widespread in frogs and toads that don't reproduce like this. To see how far back in evolution the behaviour might go, Brischoux and his colleague Léa Lorrain-Soligon used a database containing 280 records of misdirected amplexus across 159 frog species. They plotted these records across a frog evolutionary tree and then used a probability analysis to calculate when the behaviour probably first appeared.

"It would be advantageous for males to be attracted to any female-looking object"

They found a very high likelihood – over 97 per cent – that the earliest frog species made these kinds of mistaken matings. This species is estimated to have lived about 220 million years ago (*Biological Journal of the Linnean Society*, doi.org/ktdj).

"Our results suggest that the reproductive strategies promoting misdirected amplexus were possibly occurring early during [frog and toad] diversification," says Brischoux.

"Studies like this further support the idea that even the most evolutionarily divergent frog lineages share highly conserved behaviours," says Aryeh Miller at Washington University in St. Louis, Missouri.

It is possible some amphibians were getting it wrong even earlier and that the ancestor of all amphibians, including salamanders and caecilians, could have been doing it, says Filipe Serrano at the University of São Paulo in Brazil. "But so far, reports of misdirected amplexus by salamanders are lacking."

The number of references to misdirected amplexus in the scientific literature has grown exponentially since the start of the 21st century, says Brischoux. A rise in habitat modifications, droughts and human-caused environmental noise may be partly responsible, he says.

"The possibility that anthropogenic activities may promote the occurrence of this reproductive dead end is worrying at a time when amphibian populations are suffering a strong decline," says Brischoux. ▮

Technology

Thousands of people apparently cheat at Wordle every day

Jeremy Hsu

A SURPRISING number of people solve the daily word-guessing game Wordle on the first try – suggesting that some are cheating.

Wordle, owned by *The New York Times*, challenges you to guess a five-letter word within six tries and has about 2 million English-language players. James Dilger at Stony Brook University in New York has compiled and analysed daily data on players' guesses, provided by the official WordleBot software, from between May and August.

The Wordle target word list contains 2315 words, so the odds of guessing the word the first time should be about 0.043 per cent. At best, 860 out of 2 million Wordle players should be getting lucky.

Instead, the daily percentage of first-guess solvers never went below 0.2 per cent, or about 4000 people. On some days, it was as high as 0.5 per cent, or about 10,000 (arXiv, doi.org/ktdk). This chimes with research showing that people look for Wordle answers on Google.

WIRESTOCK/SHUTTERSTOCK

A suspiciously high number of people guess the Wordle word on their first try

Dilger's study also shows how about one-third of Wordle players consistently use the same starting word, even after that word has featured as an answer and so won't be the solution to the current game.

Staying loyal to an opening word can have strategic value to narrow down the target word, says Kelli Dunlap at American University in Washington DC. Not everyone is there for the playful challenge, she says. "I play Wordle every day. My 7-year-old waits till I get it, so that he can get it right on the first try." ▮

Great moments in future science
Hear Karl Kruszelnicki's predictions on 8 October
newscientist.com/nslmag

Communications

China's city-wide quantum network

A network connecting quantum devices in Hefei can allow multiple secure chats at once

Karmela Padavic-Callaghan

THE most advanced quantum communication network yet has been created in the city of Hefei, China. Comprising three quantum devices and a central server, it is as close to an unhackable quantum internet as we have yet achieved.

Built by Jian-Long Liu at the University of Science and Technology of China and his colleagues, the network shares some features with conventional communication networks, such as transmitting information through optical fibres. But the light travelling in the quantum network comes in chunks whose quantum states encode the information. This means the property of quantum entanglement can be used to make it nearly impossible to surreptitiously copy or alter the information, making the whole network exceptionally secure.

Similar quantum networks have been built before, but this one stands out because of how many potential users could connect their own quantum processor to it and because of the kind of devices, like quantum memories, that it includes.

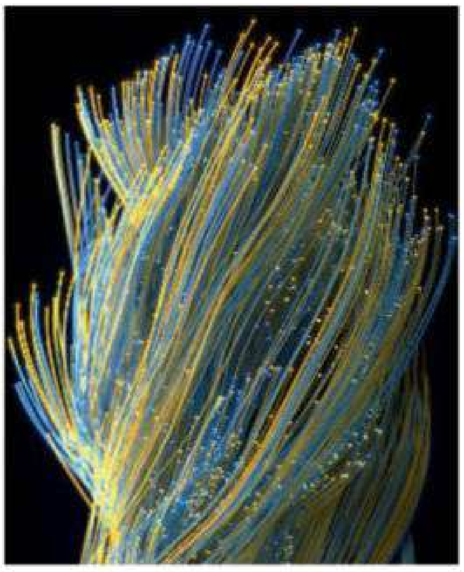
The users at the three devices, each of which has a processor and a quantum memory, can encode information into photons, or units of light, and send them to the central server. The server can then manipulate the photons – for example, by entangling them – and send them back to the users.

Each user's quantum memory is made from extremely cold rubidium atoms, which are controlled with lasers, and information can be encoded into each atom's quantum state. That is important, because if a photon sent to the server gets lost or corrupted, the atoms can still hold on to the information that the photon was meant to carry.

Within the network, the team successfully entangled photons from two distant nodes, which is a necessary first step for the two to securely share information. The network could also sustain entanglement between more than one pair of users at once, enabling multiple secure quantum chats at a time (arXiv, doi.org/ktf2).

Mehdi Namazi at New York-based quantum communication start-up Qunnect says that combining devices like processors, fibres and memories has previously been too complicated because the properties of the photons must be tweaked and readjusted at many points in the network, so there are many possible points of failure. Past experiments hinted at promising steps towards building a network, but this is a true "networking mega experiment", he says.

The quantum network transmits information through optical fibres



KMLS/SHUTTERSTOCK

"This is a very interesting milestone on the road to the quantum internet," says Siddarth Joshi at the University of Bristol, UK. He says quantum memories are the most crucial component because they haven't featured in a network of this scale before. They are widely considered essential for making quantum communication networks large enough to connect cities.

However, Joshi says the rate at which information can be shared throughout the quantum network in Hefei needs to be improved for the network to become useful. It can transmit roughly 1 bit per second, or less than a thousandth of what dial-up modems from decades ago could.

"The main challenge in making networks like this cover even longer distance and have even more nodes is in improving the quantum memories," says Tian Zhong at the University of Chicago. He says improving the memory storage times would enable the network to transmit more information faster. ▮

Technology

Cyborg cockroach could help in search-and-rescue missions

A CYBORG cockroach controlled by an electronic backpack, which attaches to its antennae and abdomen without injuring it, could be used for building inspections or search-and-rescue efforts.

Electronically controllable cockroaches aren't new, but all previous work has required invasive surgery to implant an electrode directly into the insect's nervous system.

As well as potentially causing pain, implantation can damage the cockroach and limit the amount of time that the electronic controls work to minutes or hours.

Now, Hirotaka Sato at Nanyang Technological University in Singapore and his colleagues have developed flexible electronic sleeves that slip onto the cockroaches' antennae and can deliver a signal to guide them in a certain direction.

"With this research, we can operate for hours and days probably – long operation is possible," says Sato.

The electronic sleeves are made from layers of gold and plastic and are fixed in place using ultraviolet light, similar to shrink-wrap plastic that tightens with heat.

While the antennae's electrodes are used for steering, a third electrode attached to a cockroach's stomach can make it speed up or slow down.

Sato and his team showed they could control a cockroach's path around an S-shaped track and an obstacle course of random stones (*npj Flexible Electronics*, doi.org/ktpr).

"Cyborg insects could be used for security and hazardous infrastructure inspection"

Because the antennae were undamaged and functional while wearing the sleeves, the cockroaches could still use them to navigate around the course, as well as receiving information from the researchers via Bluetooth.

"Cyborg insects can be used not only for search-and-rescue missions, but also security and hazardous infrastructure inspection," says Sato. ▮

Alex Wilkins

Health

MDMA expected to get US approval as therapy for PTSD

Jason Arunn Murugesu

A THERAPY for post-traumatic stress disorder (PTSD) using the drug MDMA is likely to be approved by US regulators in the next year, after the largest clinical trial to date found it was safe and effective in a diverse group of participants.

PTSD is estimated to affect 3.9 per cent of people worldwide at some point in their lives. The only pharmaceutical drugs approved to treat the condition in the US are antidepressants.

"A lot of people with PTSD are depressed and so these drugs target that depression," says Jennifer Mitchell at the University of California, San Francisco. But this just lessens the symptoms, rather than dealing with the cause, she says.

Numerous studies have investigated whether MDMA, also known as ecstasy, could be used in psychotherapy to help people with PTSD. The drug puts people into a more relaxed and trusting state and dampens fearful responses when they recall past trauma, helping them to engage more openly with therapists.

"This confirms that MDMA plus psychotherapy is an effective treatment for PTSD"

"We know that MDMA facilitates the retrieval and then the reconsolidation of fear memories within the amygdala [part of the brain that regulates emotion]," says Mitchell. "And so somehow in this process of retrieval and reconsolidation, it seems that you are shedding some of the emotionality associated with the memory."

In June, Australia became the first country in the world to allow doctors to prescribe MDMA for PTSD alongside psychological support.

SDI PRODUCTIONS/GETTY IMAGES

The experiences of soldiers can lead to them developing PTSD

Mitchell and her colleagues previously showed that MDMA-assisted psychotherapy is effective in a trial involving 90 people, most of whom were white, with severe PTSD.

The latest study involved 104 people in the US and Israel diagnosed with moderate to severe PTSD, of whom 27 per cent identified as Hispanic or Latino and 7 per cent identified as another ethnicity or race other than white. This group is more representative of people with PTSD in the US, so the results can give more confidence that the treatment will work in a wider population, says Mitchell.

In the study, the participants all received three therapy sessions spaced a month apart. Half the group received a dose of MDMA with their therapy sessions, while the other half received a placebo pill.

Following the three therapy sessions, 71.2 per cent of the MDMA group no longer met the diagnostic criteria for PTSD, compared with 47.6 per cent of the placebo group (*Nature Medicine*, doi.org/gsqm7s).

In 2017, the US Food and Drug Administration (FDA) named MDMA-assisted psychotherapy as a "breakthrough therapy". This meant regulators worked with the research sponsors to design the clinical trials so they would deliver the evidence needed for the approval process. As a result, the treatment could receive FDA approval early next year, says Mitchell.

"These are very encouraging results," says Allan Young at King's College London. "Although the benefits and harm should be confirmed in further research, this study brings this new treatment much closer to clinical use."

"The latest study confirms what the previous ones have shown: that MDMA plus psychotherapy is an effective treatment for PTSD," says David Nutt at Imperial College London. "Such evidence is why the Australian government has already rescheduled MDMA for PTSD. To save lives and reduce suffering, the UK should rapidly do the same." ▮

Biotechnology

DNA computer could scan living cells for diseases

Karmela Padavic-Callaghan

A LIQUID computer can use strands of DNA to run more than 100 billion different simple programs. It could eventually be used for diagnosing diseases within living cells.

Fei Wang at Shanghai Jiao Tong University in China and his colleagues have modelled how to combine short segments of DNA into larger structures that could serve as circuit components, like wires, or function to direct those wires to form different configurations, similar to what happens on a silicon computer chip.

To test this, they filled tubes with DNA strands and a buffer fluid and let the strands attach to each other, combining into larger molecules through chemical reactions. The researchers also equipped all the molecules with fluorescent markers so they could keep track of what the circuit was doing based on how its parts were glowing.

They called the building blocks of their computer DNA-based programmable gate arrays (DPGAs), and each DPGA could be designed to implement more than 100 billion distinct circuits by adding different short molecules into its tube.

In one experiment, the researchers connected three DPGAs, comprising about 500 DNA strands, to make a circuit that solves quadratic equations. In another, they made a circuit for calculating square roots. They input numbers by adding molecules of a specific shape that then participated in chemical reactions with molecules that made up the circuit, analogous to an electron moving through wires. The outputs of each circuit were molecules produced by the final reaction, which the researchers could read by measuring their fluorescence (*Nature*, doi.org/ktbh).

Such DNA computers could offer a way to diagnose diseases through contact with body fluids or even from within cells, says Wang. ▮

New Scientist Live
Save Britain's rivers!
Hear Feargal Sharkey and Graham Lawton on 8 October
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Environment

English rivers pumped with oxygen...

The Environment Agency has been deploying emergency measures to stop fish suffocating

Jason Arunn Murugesu

RIVERS in England were pumped with emergency oxygen in an attempt to save fish from dying on almost 100 occasions in the past five years, *New Scientist* can reveal.

Waterways can become deoxygenated for many reasons, including sewage dumping that encourages the growth of bacteria, plants and algae, which can result in the consumption of oxygen. Hot weather can also play a role, because water holds less oxygen at higher temperatures.

To combat these effects, the Environment Agency (EA) has emergency measures in place in England to pump oxygen into rivers with the aim of preventing fish and plant deaths.

Last year saw 25 instances of the EA doing this, according to a freedom of information request, and there were 74 deployments between 2018 and 2021. The figures for this period include only 13 of the EA's 14 operating areas, and data isn't yet available for 2023, so there were at least 99 emergency oxygen deployments in the past five years, and the true figure is likely to be higher.

Graeme Storey, fisheries manager at the EA, says the organisation hasn't officially analysed whether the use of those emergency measures has increased, but says that anecdotally it seems like it has. "It does feel as though the number of reports received of fish in distress has increased over recent years," he says. "The signs to look out for are fish gasping for air, appearing lethargic in the margins and dead fish floating on the surface."

The EA raises river oxygen in several ways, such as using liquid hydrogen peroxide, which breaks down into water and oxygen, and mechanical aerators, which boost oxygen levels by disturbing the surface. "Used in isolation, mechanical aeration is slower to raise oxygen levels, but it is a great option for chronic issues such as regular algal blooms," says Storey.

Climate change is likely to increase the need for emergency oxygen in rivers in the future, says Storey. "There are two factors at play here, increasing temperatures and extreme rainfall events acting in combination with underlying pressures on the aquatic environment," he says. "If global temperatures continue to rise and stay higher for longer periods, this will cause ongoing challenges for wild fish populations and fisheries."

"The use of emergency aeration shows that fish populations in a number of England's rivers are on life support," says Gary Caldwell at Newcastle University, UK. "Our changing climate is expected to bring increasingly prolonged periods of low rainfall, which, compounded by sewage and agricultural runoff, could mean that artificial oxygenation becomes the new normal."

"Oxygen pumping is an important emergency measure in fish rescue, but keeping rivers cool, protecting flows and reducing pollution are all important longer-term measures to protect rivers against the impacts of climate change," says Steve Ormerod at Cardiff University, UK. ▮

Emergency oxygenation at a fishery in Claines, Worcestershire, UK, last year

THE ENVIRONMENT AGENCY

...while river oxygen levels fall across US and Europe

RIVERS in the US and central Europe are rapidly losing oxygen due to rising temperatures, and the problem will get worse.

Li Li at Pennsylvania State University and her colleagues have reconstructed daily oxygen and temperature levels for 796 rivers in the US and in central European countries, such as Austria and Hungary, between 1981 and 2019.

Assessing past oxygen levels accurately is difficult because there is a lack of high-quality daily data on rivers, says Li. So, she and her colleagues combined a wide range of data sources for hundreds of rivers, including water temperature and oxygen level, weather information for the river locations and data about surrounding land.

The researchers then used a machine-learning model to integrate this data and produce estimated daily oxygen and temperature levels for the 796 rivers. They statistically validated the estimates against the 25 per cent of existing data they didn't use.

The researchers found that 87 per cent of the rivers had been getting warmer over the past four decades and 70 per cent had been losing oxygen. "For any liquid, if it's warmer, its capacity for holding gases is smaller," says Li.

While urban rivers warmed the fastest, oxygen loss happened quicker in rivers running through agricultural areas (*Nature Climate Change*, doi.org/ks98).

70%

Proportion of rivers with falling oxygen levels, out of 796 analysed

Healthy rivers typically have a dissolved oxygen level above 8 milligrams per litre. Levels below 3mg per litre are hypoxic and pose an acute danger to fish, says Li.

The researchers used their model to project oxygen levels until 2100. It showed that deoxygenation rates in the rivers will be 1.6 times higher on average than historical conditions if temperatures rise by 2.7°C by the end of the century. Li says that Brooker Creek in Florida, for example, has about 204 days a year of hypoxic conditions and this number will rise by 5.7 days per decade. ▮ **JAM**

Health

Key immune cells may protect against Crohn's disease

Jason Arunn Murugesu

A GROUP of specialised immune cells in the gut may help control the progression of Crohn's disease.

Crohn's disease is one of two main forms of inflammatory bowel disease (IBD) that together affect roughly 1 per cent of adults in the UK and the US. However, very little is known about what actually causes them, says Adrian Hayday at the Francis Crick Institute in London.

Immune cells in the gut are thought to play a role, particularly ones called gamma delta T-cells, he says. Hayday and his colleagues wanted to see what these cells look like in the guts of people with IBD compared with those with healthy guts. To do this, they took gut lining samples from 150 people who were undergoing a colonoscopy, some of whom had IBD.

Those with IBD generally had lower numbers of a subset of these immune cells, called V-gamma-4 (Vg4) cells, than people with healthy guts. The cells are largely found in the gut lining, says Hayday.

But it wasn't simply the case that those who had fewer Vg4 cells were more likely to have IBD. Instead, specifically for people with Crohn's disease, people with fewer of these immune cells in the gut were likely to have more severe disease.

In people who were in remission from Crohn's disease, those with Vg4 cells that looked like those in healthy guts were less likely to relapse in the next five years (*Science*, doi.org/gsqm5k).

"These cells are not going to stop you getting the disease, but they're going to give you a better response to it," says Hayday. "It's sort of like a vacuum cleaner: if you've got a good vacuum cleaner, you can keep on top of things."

Spotting the cells could help doctors determine if people have a type of IBD that is likely to relapse, says team member Robin Dart at King's College London. ▮

Space

The universe's evolution seems to be slowing down

Leah Crane

THERE may be something wrong with our models of the cosmos. The matter in the universe is getting clumpier, but it appears to be happening more slowly than expected. This slowdown in the evolution of the large-scale structure of the universe could point to new particles or fields, or it could indicate that our understanding of dark matter isn't quite right.

The evolution of the universe is largely governed by the push and pull of two competing forces: dark energy forces the entire cosmos to expand, while gravity pulls matter together. According to the most widely accepted model of cosmology, called lambda-CDM, this should mean that over time, the cosmic web of galaxies gets denser and denser while cosmic voids grow and empty of matter.

But when Nhat-Minh Nguyen at the University of Michigan and his colleagues put together data on the structure of the early universe and its more recent state from a variety of sources – including galaxy surveys and measurements of relic light from just after the big bang – they found this process of structure growth has been slowing down at an unexpected rate. The cosmic web is getting denser and the voids are getting bigger and emptier, but not as fast as lambda-CDM would predict (*Physical Review Letters*, doi.org/gsp97t).

"What is causing this could be something that requires new fields, particles or interactions"

"Many different probes that are probing the universe at different times and different scales each suggest the same thing, which is that the growth of structure at recent time has been much more suppressed than we expect from the standard model," says Nguyen. "We know that we should expect some slowdown, but we find that the slowdown is more prominent than we expected."

Structures like the Heart Nebula are clumping up slower than expected

JAVIER ZAYAS PHOTOGRAPHY/GETTY IMAGES

The team's measurements are in tension with the standard model at a level of 3.7-sigma, meaning that there is a probability of about 1 in 4600 that a pattern of data like this would show up as a statistical fluke if the standard model correctly described the cosmos. A suppression in structure growth could also explain other tensions that have shown up in past cosmic observations.

"They didn't use all of the datasets that are out there, but looking at some of that updated data, I think it might have made their conclusions even stronger," says Mike Hudson at the University of Waterloo in Canada. "There are many suggestions in the literature that lambda-CDM is wrong in some way, but most of them are not widely accepted in the community – this one has earned a little more attention."

Where the slowdown comes from, and how we must modify the standard model to account for it, is a mystery. "Many of the models of modified gravity that we know would produce a structural enhancement rather than a suppression," says Jiamin Hou at the Max Planck Institute for Extraterrestrial Physics in Germany. "Seeing suppression instead is a very interesting hint to what might be going on."

"What could be causing this could be something that requires new fields, which means new particles or new interactions, which means new forces, possibly between dark matter particles," says Nguyen. If dark matter interacts or decays differently than we predicted, it might account for the measurements, but we will need more observations to know for sure. ▮

New Scientist Live
Quantum gravity
See Eugene Lim discuss the hardest problem in physics
newscientist.com/nslmag

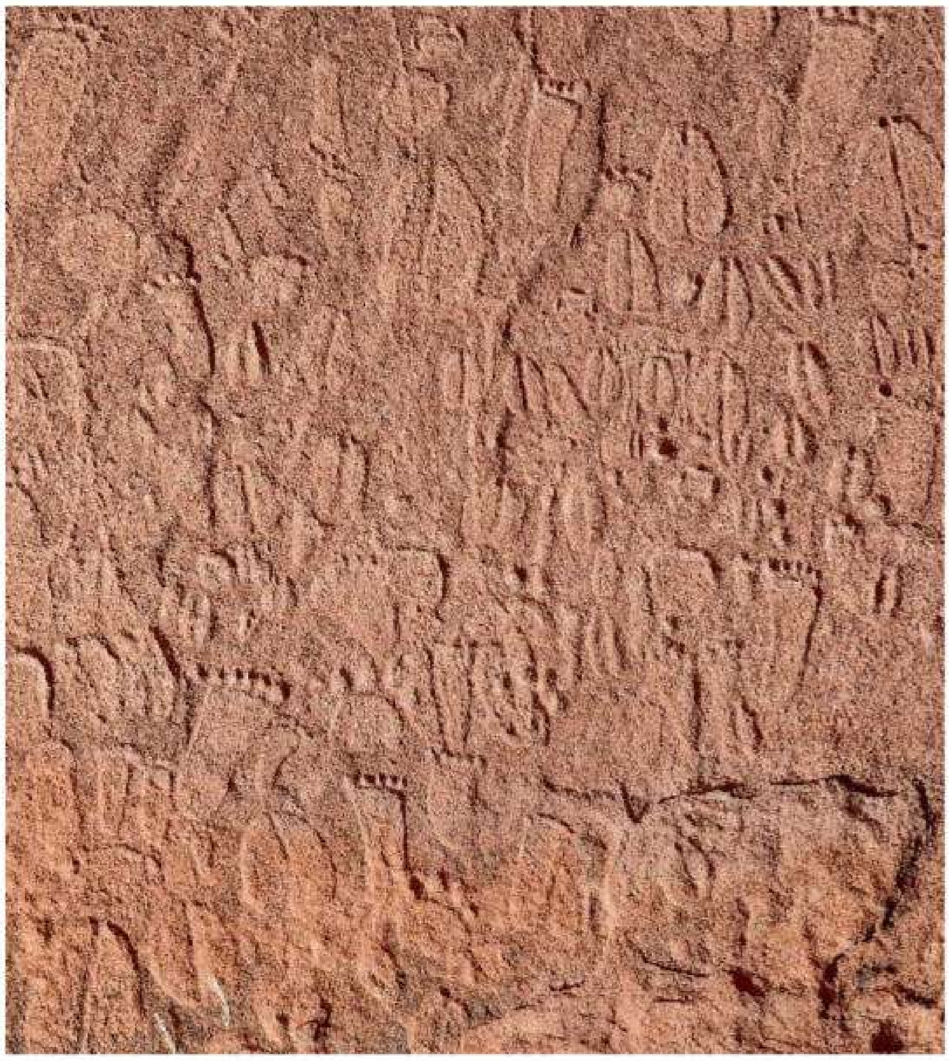
Pollution

Microplastics could threaten ozone layer

TINY particles of plastic may float higher in Earth's atmosphere than previously thought.

Gholamhossein Bagheri at the Max Planck Institute for Dynamics and Self-Organization in Germany and his colleagues have measured how microplastics of different shapes float. They found that oddly shaped fibres fall at between a quarter and half the speed of spherical ones. When they used the findings to tweak atmospheric models, which had only included spherical particles, they found that the microplastics could waft higher than earlier predictions suggest, and potentially into the stratosphere (arXiv, doi.org/ktdn).

If these fragments were to degrade at this height due to solar radiation, they could release chemicals that damage the ozone layer, says Bagheri. **Alex Wilkins**



ANDREAS PASTOORS, CC-BY 4.0

Health

New covid-19 jab works at low dose

MODERNA has created a version of its mRNA vaccine against covid-19 that is effective at lower doses and lasts twice as long in a refrigerator.

The vaccine, called mRNA-1283, has "demonstrated encouraging results in multiple clinical studies" and the firm has now completed enrolment for its late-stage clinical trial, announced Moderna.

This latest vaccine includes only two key parts of the spike protein of the virus. Animal tests showed that linking the two parts of the spike protein produced a better response than when they were separate (*Science Translational Medicine*, doi.org/ktdp). The version of mRNA-1283 being tested focuses on the original SARS-CoV-2 virus and the BA.4 and BA.5 omicron subvariants. It will be updated to target newer variants if it gets regulatory approval.
Michael Le Page

Archaeology

Stone Age carvings of animal tracks identified

EXPERT trackers have been able to identify the species depicted in about 400 animal footprints carved on rocks in Namibia during the Stone Age. In most cases, they were also able to identify the animal's sex, the leg that made the print and whether the animal was an adult or not.

Numerous rock engravings thought to be up to 5000 years old have been found in sites around an area called Twyfelfontein in north-west Namibia. Many depict animal or human footprints, so Andreas Pastoors at the University of Erlangen-Nuremberg in Germany asked three trackers from Namibia, Tsamgao Ciqae, /Ui Kxunta and Thui Thao, to help his team study them.

The trio identified the engraved tracks as depicting more than 40 species, including rhinos, giraffes, aardvarks and porcupines. Around 60 of the tracks are those of birds, such as the secretary bird and the marabou stork.

Most species depicted are still seen in the area, but some – including blue wildebeest and vervet monkeys – are found only in areas with more water, hundreds of kilometres away.

The trackers also identified the sex depicted in about 100 engraved human footprints at the same sites, along with whether the footprints were meant to be those of an adult or child (*PLoS One*, doi.org/gsqg62).

There is no way to check if the identifications are right. However, to experienced trackers the footprints of animals are just as distinct and recognisable as the animal itself, says Pastoors. The point of the carvings is still unclear, though. "We cannot understand what the depictions were made for, there's no clue," he says. **MLP**

Really brief

MINDEN PICTURES/ALAMY

Cockatoos craft custom drumsticks

Male palm cockatoos (*Probosciger aterrimus*) tap out rhythms with sticks on trees to woo potential mates. The cockatoos have individual preferences for different kinds of drumsticks, which they make by whittling down branches with their beaks (*Proceedings of the Royal Society B*, doi.org/ks76).

Frog-like robot uses explosions to hop

A robot powered by tiny explosions can jump 20 times its own length and carry 22 times its own weight. Electrodes create a spark, igniting a mix of methane and oxygen. The result is an explosion that pushes against a membrane to help the 29-millimetre-long robot jump (*Science*, DOI: 10.1126/science.adg5067).

Biodegradable glue made from soya

A glue made from soya bean oil forms strong bonds that later dissolve, offering hope for more sustainable products and packaging. It can stick most materials together as well as standard epoxies, which are plastics that take thousands of years to biodegrade (*Nature*, doi.org/ktdv).

HOPS...
SPRING...
ETERNAL.
ROB MURRAY

When a Yorkshireman finds a source of pure spring water, he doesn't bottle it. He builds a brewery on it.

In 1863 Timothy Taylor was given the opportunity to buy land over a natural aquifer spring. He immediately did what any good Yorkshireman would, and set to work building a brewery. Ever since, The Knowle Spring has been the source of the unique Pennine spring water we use to brew our beers. It has filtered slowly through layers of black rock and limestone and is said to have a taste like melted snow. Very pure and consistent water means we're able to brew beer with a finely balanced flavour and reliably high quality. After that first sip you might agree.

All for that taste of Taylor's

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Aperture
Recreating 19th-century paintings of Mont Blanc p22

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Jacob Aron explores galaxy-sprawling game *Starfield* p28

Comment

The new evolution

Our creation of artificial intelligence has unleashed a third evolutionary process that is adapting for its own benefit, not ours, warns **Susan Blackmore**

WE HUMANS are in trouble. We have let loose a new evolutionary process that we don't understand and can't control.

The latest leaps forward in artificial intelligence, with its large language models and deepfakes, are rightly causing anxiety. Yet people are responding as though AI is just one more scary new technology, like electricity or cars once were. We invented it, the argument goes, so we should be able to regulate and manage it for our own benefit. Not so. I believe that this situation is new, serious and potentially dangerous.

My thinking starts from the premise that all design anywhere in the universe is created by the evolutionary algorithm. This is the simple, three-step process in which some kind of information is copied many times, the copies vary slightly and only some are selected to be copied again. The information is called the replicator, and our most familiar example is the gene.

But genes aren't the only replicator, as Richard Dawkins stressed in *The Selfish Gene*. People copy habits, stories, words, technologies and songs; we change, manipulate, recombine and pass them on in ever greater variety. This second replicator, evolving much faster than genes ever could, Dawkins called memes – and they are selfish too.

Once I had fully grasped the idea of selfish memes, I realised how profoundly it changes our notions of human minds and cultures. I wrote *The Meme Machine* in response. In this new view, we are the meme machines, and memes compete to use us for their own propagation, creating not just silly videos and maddening ads, but all of our rich, evolving cultures. Of course, we humans try to select only those memes that make us happy or healthy, but the memes don't care because they can't care.

SIMONE ROTELLA

As we face up to the recent explosion in AI, new questions arise that both fascinate and worry me. Could a third replicator piggyback on the first two? And what would happen if it did?

For billions of years, all of Earth's organisms were gene machines, until, about 2 million years ago, just one species – our ancestors – started imitating sounds, gestures and ways of processing food or making fire. This might not seem momentous, but it was. They had inadvertently let loose a second replicator and turned us into meme machines, with dramatic effects on the rest of life on Earth. Following the same principle, could a third replicator emerge if some object we made started copying, varying and selecting a new kind of information?

It could, and I believe it has.

Our digital technology can copy, store and propagate vast amounts of information with near-perfect accuracy. While we had mostly been the ones selecting what to copy and share, that is changing now mindless algorithms choose which ads we see and which news stories they "think" we would like. AIs equipped with language processing and "personalities" become ever harder to distinguish from real people as they compete with each other and with us to get our attention – and the successful ones aren't necessarily the most benign. Even though we built this amazing digital world for our own purposes, once a digital replicator takes off, its products will inevitably evolve for its own benefit, not ours.

All is not lost, though. We already cope with fast-evolving parasites such as viruses by using our immune systems, medicines and vaccines. Now, we need to build our collective mental immunity, our critical thinking and our ability to protect our attention from all that selfish information that tries to exploit us. Taking lessons from evolution, we can stop imagining we are the controllers of our accidentally dangerous offspring and start learning how to live with them. ▮

Susan Blackmore is the author of *The Meme Machine* and many books on consciousness. She is visiting professor at the University of Plymouth, UK

No planet B

The ick factor People living in urban environments are often alienated from nature and therefore find it scary and disgusting. This "biophobia" is on the rise, says **Graham Lawton**

Graham Lawton is a staff writer at *New Scientist* and author of *Mustn't Grumble: The surprising science of everyday ailments*. You can follow him @grahamlawton

A FEW weekends ago, I hosted the first of our new Discovery Tour Weekenders at Rewilding Coombeshead, a former farm tucked away in the UK's Devon countryside. Owned and run by maverick conservationist Derek Gow, the site has an extensively rewilded area filled with Eurasian beavers, water buffalo, wild boar and Exmoor ponies, as well as an animal reintroduction and breeding programme for water voles, white storks, wildcats and common cranes. It is magical, especially when the sun is out.

I am an urbanite, but I grew up in a nature-loving household and have no fear of the wild things you can encounter in the UK. I actively like insects, spiders and snakes, and I always find it amusing when people panic at the sight of a harmless moth.

But such aversion is actually no joke. Nearly 40 years ago, biologist E. O. Wilson proposed the concept of biophilia – that humans have an innate affinity with the natural world that could be harnessed in the interests of conservation. Wilson would be horrified at recent claims that biophilia's evil twin, biophobia, appears to be on the increase.

Biophobia is defined as any negative attitude towards nature, from phobic responses such as arachnophobia to more general fear, anxiety and disgust. Snakes, spiders, bats, wasps, sharks and worms commonly elicit such emotions. Biophobia may have been adaptive in the past, but it serves no useful purpose now, at least in the UK and other nature-denuded countries.

According to Masashi Soga at the University of Tokyo in Japan, there is growing evidence that many people are repelled by wild organisms that they are unlikely to ever encounter or that aren't dangerous. In 2020, for example, he surveyed 13,000 people in Japan and found high levels of disgust about and hatred of insects and other arthropods, especially among young people and those living in urban areas.

The reason for this, Soga says, is a lack of contact with nature and a consequent dearth of knowledge about wildlife. People with minimal insect identification skills were much more likely to find harmless insects such as ladybirds disgusting, for example. Urban insects are also more likely to be encountered indoors, which Soga found increased their perceived disgustingness. He calls this the "urbanisation-disgust hypothesis".

> **"A survey of 13,000 people in Japan found high levels of disgust and hatred of insects and other arthropods"**

In another study, this time of 5375 Japanese children, Soga found that those who had less contact with nature were much more likely to be afraid of or disgusted by invertebrates.

Disgust turns out to be a driver of whether people go into nature altogether. In a separate study, researchers at Tokyo Metropolitan University asked students about their levels of anxiety around outdoor activities and found, to no great surprise, that people who find wildlife more disgusting are more likely to avoid it. This all points to a vicious cycle of biophobia, says Soga, where people's negative perceptions of wildlife drive them ever deeper into fear and aversion.

So what, you might say. If snowflake urbanites don't want to go into nature, all the more for the rest of us. The problem, says Soga, is that fear and disgust can also negatively impact people's support for conservation policies, at a time when biodiversity is in freefall. Increasing urbanisation will only exacerbate levels of biophobia, and a lack of contact with nature alienates people from the many mental and physical health benefits it can bring.

There are solutions. The Tokyo Metropolitan University study found that students who had an aversive experience with nature as a child were actually less likely to be disgusted by nature as young adults. Those who grew up with open, green spaces nearby were similarly inoculated against biophobia. Even minimal contact with quasi-nature through gardening increases biophilia and leads people to see invertebrates as beneficial rather than pestilent.

All of this speaks to two related concepts that worry me about humanity's role in biodiversity conservation. One is the "extinction of experience" – the loss of direct interactions between people and nature. The other is "shifting baseline theory" – the idea that as nature is decimated, what people perceive as natural is defined by their diminished experience of it. Both lead us to become alienated from nature and accept a reduced natural realm.

Places like Coombeshead may not solve the problem of biodiversity loss. But they can do a lot to attenuate biophobia. Spend a night in a tent full of moths, watch beavers at sunrise, walk knee-high in wild plants among wild horses and feel the full experience of what nature once was and can be again. Rewilding the countryside is only half of it. We need to rewild ourselves, too. ▮

Graham's week

What I'm reading

I'm finally clearing out my late wife's bookshelf. We didn't share the same taste in reading, but I'm sure I'll find something to remind me of her.

What I'm watching

The new season of Top Boy *on Netflix.*

What I'm working on

Training my new cat to stop lying on my laptop when I'm working from home.

This column appears monthly. Up next week: Annalee Newitz

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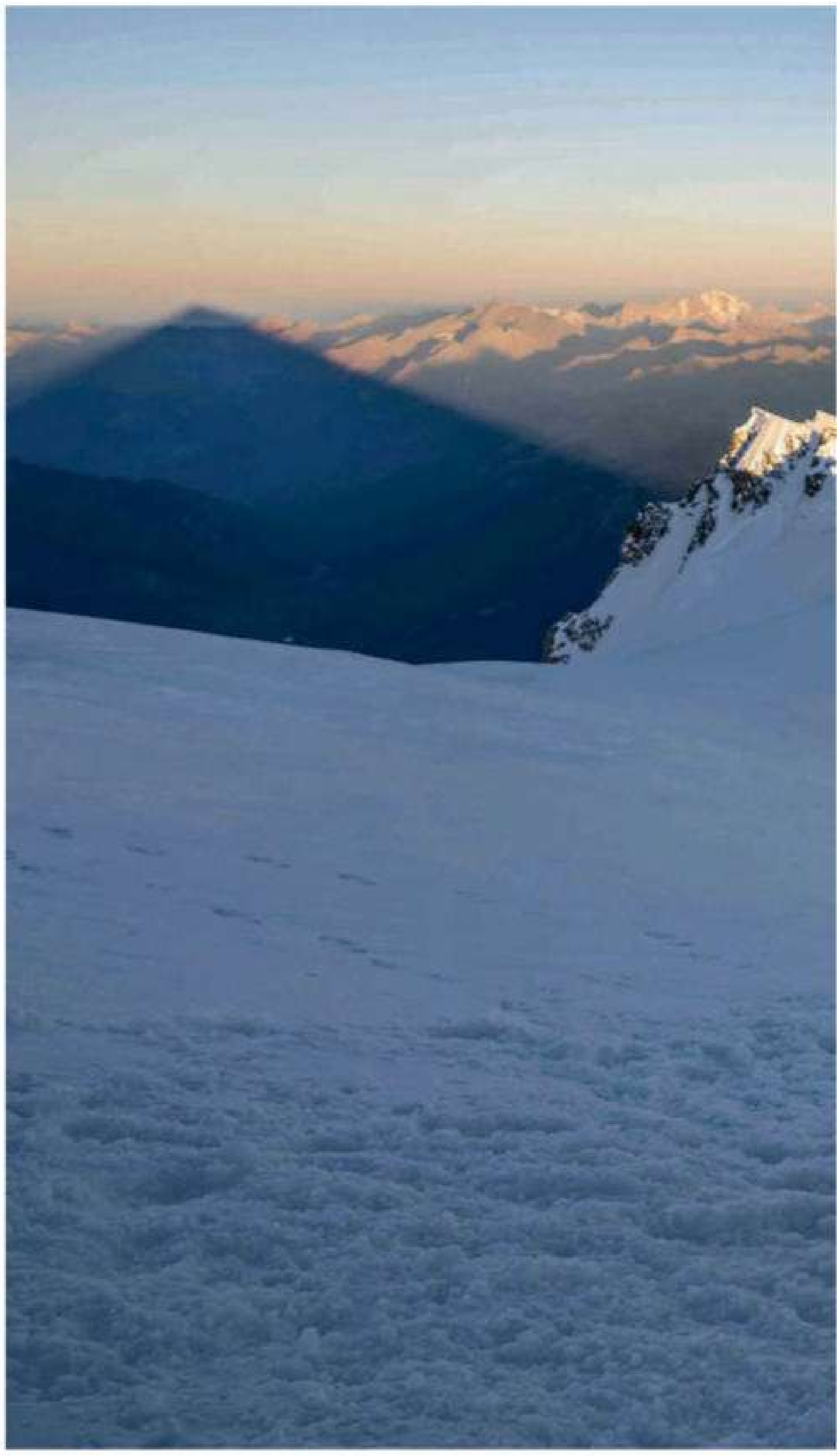

Peak condition

Paintings James Hart Dyke and Gabriel Loppé
Photos Pascal Tournaire and Richard Ivey

AS THE sun began to set, framed by one of Europe's most prominent mountains, it became even more imperative for painter James Hart Dyke to reach the summit.

His mission, captured here, was to scale Mont Blanc in the Alps and recreate the summit paintings of 19th-century artist Gabriel Loppé, known for his work created atop mountain peaks. After two years of planning by Loppé scholar, climber and art dealer William Mitchell, Hart Dyke set off up the mountain in July 2022, following as similar a route as possible to the one Loppé took in 1873 to create his own summit artwork. A piece by Hart Dyke is shown at the bottom of the far left column, with one of Loppé's paintings above it.

The changing climate has meant scaling peaks like Mont Blanc is "far more dangerous and unpredictable than ever before", says Mitchell. Melting glaciers and increasingly unstable weather conditions pose a very real threat to the future of climbing and the integrity of the mountains themselves, and today's Alpine landscape is a far cry from that in Loppé's time. "What struck us most was the frequency of avalanching ice, tumbling seracs [glacial ice columns] and the width and depth of the crevasses which have opened up," says Mitchell.

Hart Dyke is pictured in his studio in Brighton, UK (top left), at Mont Blanc's Bossons glacier (top right), climbing with his team (top centre) and painting the summit view in the main image. Works from the expedition, along with Loppé's art, will be shown in MONT BLANC: The summit paintings at Cromwell Place, London, from 27 September to 8 October.

Gege Li

Editor's pick

On the starting point for a new geological epoch

9 September, p 21

From Jan Zalasiewicz, Martin Head, Simon Turner, Colin Waters and Mark Williams, Anthropocene Working Group

Erle Ellis says formal recognition of an Anthropocene Epoch beginning in 1950 would be damaging in that it denies earlier human impacts. It does no such thing. Such impacts – from hunting, farming and urbanisation – go back through and characterise the 11,700 years of the Holocene (and some into earlier times). But they didn't disrupt the overall stability of the climate, sea level and biosphere.

The Anthropocene as a potential new geological epoch represents something quite different: a marked and rapid change from the relative stability (sustained over millennia) of the Holocene into another planetary state, one of sharply disrupted global chemical cycles, intensifying global warming, a reconfigured biosphere and countless globally dispersed novel materials, including pesticides, plastics and artificial radionuclides.

Driven from the mid-20th century on by industrialisation, technological advance, population growth, fossil fuel burning and globalisation, this change is indelibly imprinted into recent geological deposits. Much is now irreversible: the planet has no way back to a Holocene state.

This Anthropocene concept has a coherence, reality and significance that justifies formalisation, to stabilise its meaning and use in communication. To obfuscate the meaning of this recent planetary change by hiding it within all human impacts through all time, rather, would damage science.

From Dave Smith, Alnwick, Northumberland, UK

Instead of using a 1950s sedimentary layer in a lake in Canada to define the start of the Anthropocene, I suggest that the appearance of lead in Greenland ice is, at least, a measurable and significant marker of our activity.

Lead levels in Greenland ice became significant from 1000 BC, but they skyrocketed when leaded fuel was introduced and became widely used in the 20th century.

Thirsting for truth on water-gobbling crops

26 August, p 36

From Guy Cox, Sydney, Australia

Your story on the breakdown of the water cycle states that one cup of coffee requires 140 litres of water to produce. I have tried to reverse-engineer this claim using rainfall data and crop yields, and this is only explicable on the basis that every drop of rain that falls on a plantation is somehow taken out of circulation. Clearly, it isn't.

Coffee is a crop like any other, and some of the rain that falls will be taken up by the bushes and transpired (so is still in the water cycle) and the rest will run off into streams and rivers. Since all we are harvesting are the "cherries" – the bushes are perennial – what we are taking out of the system is tiny. We would take out more by growing cabbages, as we eat the whole thing.

From Bryan Simmons, Bratton, Wiltshire, UK

You say it takes 12,651 litres of water to produce 100 grams of vanilla beans. Clearly that doesn't all end up in the beans. Surely at least some ends up in the atmosphere or in groundwater.

More reasons not to get power from ocean warmth

Letters, 26 August

From Van Snyder, La Crescenta, California, US

Glenda Dixon asked: "Why not use thermodynamic systems to get heat from the [warming] seas to generate electricity and heat local homes?" One reason is that the devices needed would be huge because their efficiency is low.

The only example that ever worked for any length of time was built by Japan for the island nation of Nauru. It produced 120 kilowatts (not megawatts). Of that, 90 kW were used to run the device. It relied on a mixture of water and ammonia, which poses a significant environmental risk if it leaks out.

'Alien object' could just be a volcanic plug

2 September, p 29

From Jim McHardy, Clydebank, West Dunbartonshire, UK

It has been suggested that the elongated interstellar object 'Oumuamua was sent to our solar system by advanced alien life.

However, natural explanations seem more likely. Lava solidifying in a volcano conduit often takes up a rod-like 'Oumuamua shape. Erosion of the surrounding rock leaves the frozen lava as a volcanic plug. 'Oumuamua could have formed like this on a distant planet. A later collision with another object could have ejected the plug into space. Or the close pass of its planet to a star may have increased the temperature and pressure of magma so much that it fired a rod of frozen lava upwards from a volcano fast enough to escape from a small planet.

The white roof fan club is getting bigger

Letters, 2 September

From Robert Checchio, Dunellen, New Jersey, US

Reader Geoff Hammond might not see white roofs where he lives in the UK, but here in the US they aren't uncommon, or at least they are a choice. When having our roof reshingled a few years back, we opted for the whitest shingle available. The results are plainly visible in the view from Google Earth. Our attic has stayed much cooler since the reroofing.

From Roger Stapleton, St Andrews, Fife, UK

Hammond suggests a lick of climate-friendly white paint on the roof. I did this about 30 years ago when my garage roof was replaced. It made a huge difference to the temperature in the garage, making it cooler in summer sunshine and less cold in winter. I agree – more people should do it. On a flat roof, nobody would really notice, so they would be unlikely to complain!

If you can't make it at home, it's ultra-processed

19 August, p 16

From Christine Dann, Diamond Harbour, New Zealand

Why is it so hard to define what is meant by ultra-processed foods (UPFs)? These comprise any edible substance made using ingredients not used by (or available to) home cooks, processed by methods not possible in home kitchens, or both of these.

Incidentally, yogurt that is made in the traditional way is most definitely not a UPF, and I don't think it should have been used to illustrate the story.

What lies beyond the Zone of Utter Ignorance?

2 September, p 47

From David Foreman, Welcombe, Devon, UK

I would like to make a change to cartoonist Tom Gauld's diagram of knowledge. Beyond the "Zone of Utter Ignorance" – in the interests of topicality and with half an eye on the future – should be added the "Event Horizon of Conspiracy Theory". ▮

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Who were the Neanderthals?

How we see our closest extinct relative says as much about us as it does about them, argues an intriguing new book. **Alison George** explores the territory

Book

The Naked Neanderthal

Ludovic Slimak

Allen Lane

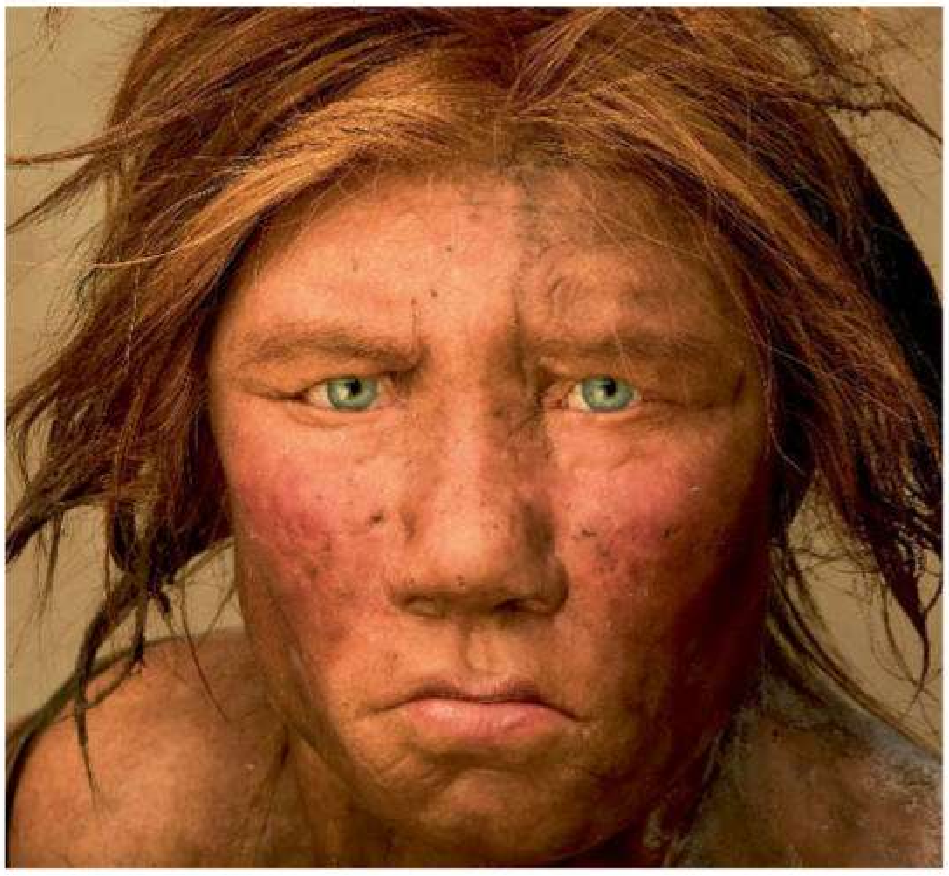
FOR most of our existence, *Homo sapiens* shared the planet with other types of human: the mysterious Denisovans, the diminutive "hobbit" *Homo floresiensis*, the Neanderthals and perhaps others. But for the past 40,000 years, after our closest relatives, the Neanderthals, died out, we have been alone.

"The Neanderthal no longer exists, except in our minds," writes Ludovic Slimak in *The Naked Neanderthal*, published to great acclaim in France last year and now available in English. This statement is particularly true for him as a palaeoanthropologist, based at the University of Toulouse in France, who has spent much of the past 30 years in caves haunted by Neanderthal remains, investigating their rituals of life and death. What can this tell us about these extinct intelligences and their view of the world?

The existence of this extinct species was first revealed in 1856, with the discovery of a skeleton in Germany. Boasting robust physiques and pronounced brow ridges, the Neanderthals, as we came to call them, were depicted as brutish thugs with vastly inferior intellectual capabilities to ours.

This perception has radically changed since the discovery that they used complex techniques, such as making adhesive from birch tar, as well as apparently burying their dead and creating cave art. In this narrative, you probably wouldn't spot a Neanderthal on the subway if they wore a suit and a hat.

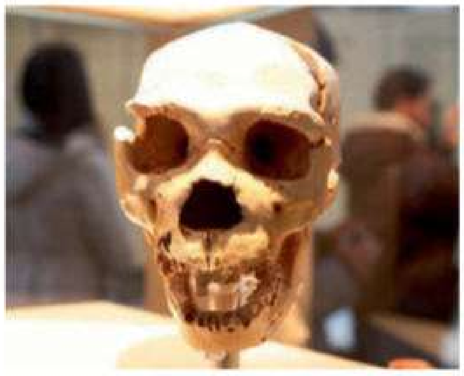
But for Slimak, this rehabilitated view is equally problematic, based not on true understanding, but on a construct that says more about us than them. "We have sought projections of ourselves in the Neanderthals," he writes, arguing that their consciousness was fundamentally different from our own.



JOE MCNALLY/GETTY IMAGES

An artist's impression of a Neanderthal woman (above); a Neanderthal skull

Surprisingly, Slimak is sceptical of the evidence that Neanderthals created cave art and symbolic objects such as necklaces of shell beads. Likewise, while he has no doubt they buried their dead, he argues this won't help us understand them, as we know that empathy and sorrow for the deceased is shared by some other animal species.



MIKE KEMP/GETTY IMAGES

Instead, he finds unique insights through an exhaustive excavation he conducted of a rock shelter near Mount Ventoux in France – a Rosetta Stone of the Neanderthal world. The excavation turned up some astonishing discoveries in a 12-metre-deep patch of soil dating from between 80,000 and 123,000 years ago, which records events in a time of great climatic change.

Trapped in the sand were the well-preserved remains of hunts – there were 61 different prey species, from lions to turtles. Neanderthals not only hunted dangerous beasts but also ones with more complex behaviours, which entailed very different hunting strategies. This, says Slimak, contradicts the idea that Neanderthals couldn't adapt to target different prey in the face of climate change – one proposed explanation of their demise.

Most fascinating was evidence in a layer of soil deep in the cave, where there is no sunlight. Here, the fossil bones came from deer carried in by Neanderthal hunters.

> **"Did Neanderthals eat their dead during famine, or was it a ritualised handling of dead bodies?"**

But while most hunts include young and old, male and female prey in equal measure, this layer contained only mature male deer, with a large number of skulls with antlers attached – possible hunting trophies. For Slimak, this points to a Neanderthal ritual: the systematic targeting of the trickiest specimens to kill, perhaps as a rite of passage.

Equally fascinating is evidence that may suggest cannibalism and signs of flesh stripping. But did the Neanderthals eat their own kind out of desperation during famine, or was it a ritualised handling of the bodies of the dead?

Like so many aspects of the lives of Neanderthals, this is hotly contested. As is the cause of their extinction: having rejected a failure to adapt under climate change, Slimak places the blame firmly on the superior weaponry of *Homo sapiens*.

The Naked Neanderthal sets out to free this extinct species of the prejudices we have imposed – and, as such, is a resounding success. As Slimak says: "There is no objective, logical, rational reason why these populations, which evolved independently for hundreds of millennia, should have developed ways of being in the world which are the same as ours." ▮

Speaking up for science

A personal account of dealing with the anti-vaccine movement in the US is troubling and painful, finds **Michael Marshall**

Book

The Deadly Rise of Anti-science

Peter J. Hotez

Johns Hopkins University Press

WHEN I posted a photo of *The Deadly Rise of Anti-science: A scientist's warning* on Twitter/X and said I was reading it, the result was a very unpleasant set of replies. But they were a pale reflection of those received by its author.

It is hard to see why anyone would dislike Peter Hotez. A US doctor and researcher, he has helped develop vaccines against hookworm, schistosomiasis and other conditions: tropical diseases neglected by the pharmaceutical industry. Most recently, he was one of the leaders of Corbevax, a project to develop a cheap covid-19 vaccine to give away patent-free. His work has saved thousands of lives.

Yet he is hated by some. "You will hang for crimes against humanity" is one of the milder emails Hotez has received. His "crime" is to have developed new vaccines and extolled their virtues in public.

SARAH SILBIGER/BLOOMBERG VIA GETTY IMAGES

Peter Hotez speaking at a US Congress committee hearing on covid-19 in March 2020

His book, often harrowing and deeply alarming, covers his experience of the US anti-vaccine movement, especially during the covid-19 pandemic, when Hotez was often on TV and radio encouraging people to get vaccinated. He uses the term "anti-vaccine", but many practitioners prefer "vaccine hesitancy" as less condemnatory and implicitly acknowledging that public health providers must build trust, especially among marginalised communities.

Hotez's main contention is that the US anti-vaccine movement has metastasised. What was a fairly fringe position a few decades ago is now a well-funded campaign that resists not only covid-19 vaccines, but other medical interventions too.

It has also found a political home in Donald Trump's Republican party. One of its key lines is that vaccines impinge on "health freedom". The argument goes that if parents want to send their children to school without vaccinating them, putting other children at risk of diseases like measles and polio, that is their right. This stance has found a natural home on the libertarian right. Vaccine hesitancy is mostly a right-wing phenomenon in the US, even a recruiting platform.

The grim irony is these "freedom" campaigners have aligned themselves with authoritarians. As Hotez writes, authoritarian regimes have always clamped down on experts: Joseph Stalin had Soviet geneticists murdered; Hungary's Viktor Orbán forced a prestigious university out of the country; US Republicans have long targeted climate scientists. Persecuting vaccinologists, says Hotez, is part of the pattern. His analysis of the modern US anti-vaccine movement and its entanglement with the authoritarian right is astute.

He is weaker on the history of vaccine hesitancy. His account starts in the 1990s with the false claims that the MMR vaccine causes autism. This keeps things personal: Hotez has an adult daughter with autism and understands better than most why the claims were untrue. But he neglects the fact that vaccine hesitancy has existed as long as vaccines, and that it takes different forms in different cultures.

There is a lot to learn from other instances of vaccine hesitancy – including, crucially, how to persuade people that vaccines are safe and beneficial. As with so much in public health, it is down to building trust between communities and institutions. Still, it is churlish to complain that Hotez doesn't know how to persuade – one of his big asks in the book is for more support (some for training programmes) for scientists who want to communicate with the public.

Hotez admits he isn't sure his media appearances swayed many Republicans. But he was right to reach out to the vaccine-hesitant. Many more will need to do so. ▮

Michael Marshall is a writer based in Devon, UK

New Scientist *recommends*

Chen Ly
Reporter
London

I recently followed **The Butterfly Trail** – a mixed-reality experience that takes you through a virtual butterfly house (pictured). Vibrant, animated butterflies flutter around on floor-to-ceiling screens. The best part was being able to "hold" the critters in my hand by using an app linked to my phone's camera that let real-time animations of butterflies land on my finger. It is a brilliant mix of nature and technology – in London's busy centre for the next six months.

PIXEL ARTWORKS

Sticking with nature, I have just watched **The Nettle Dress**, a beautiful documentary film currently on release in the UK that tells the story of Allan Brown, a textile artist who spent seven years making a dress out of nettles after his wife died. The film follows Brown as he forages for the nettles, spins the fibre and finally sews the dress together. Alongside broader environmental and ethical messages about the true cost of the textile industry, this film offers an intimate insight into the cathartic and healing power of nature.

The games column

Too many planets, too little time

Bethesda's new galaxy-sprawling game *Starfield* gives you 1000 planets to explore. But with many of these worlds generated by algorithm, it can all feel a bit dull and predictable, finds **Jacob Aron**

Jacob Aron is *New Scientist*'s news editor. Follow him on Twitter @jjaron

Game
Starfield
Bethesda Game Studios
PC, Xbox Series X/S

Jacob also recommends...

Games
The Elder Scrolls V: Skyrim
Bethesda Game Studios
PC, PlayStation 3, 4 and 5, Xbox 360, One and Series X/S, Nintendo Switch
If you somehow haven't played this Norse-inspired masterpiece in the 12 years since its release, it is available on almost anything that plays games.

The Outer Worlds
Obsidian Entertainment
PC, PlayStation 4 and 5, Xbox One and Series X/S, Nintendo Switch
If you are looking for a stripped-down Starfield, *this 2019 role-playing game hits a lot of the same highs.*

BETHSEDA GAME STUDIOS

Starfield **sees you travelling the galaxy looking for artefacts**

A FEW months ago, in my review of *Tin Can*, a game that takes place in a tiny spaceship escape pod, I wrote about the joy of small video games simulating a single area in exquisite detail. That has been on my mind as I play *Starfield*, a galaxy-sprawling role-playing game that does almost the exact opposite.

Starfield is the latest behemoth from Bethesda Game Studios, a developer known for its gigantic fantasy and post-apocalyptic worlds in the *Elder Scrolls* and *Fallout* series. This new title attempts to go even further, giving you 1000 planets to explore.

The moment I heard that marketing line, I was wary. We have been here before with *No Man's Sky*, a 2016 game that boasted 18 quintillion planets. Yes, that's a real number, albeit one so high that these worlds would be impossible for human developers to create. Instead, *No Man's Sky* and *Starfield* both use procedural generation to build their worlds, with sets of 3D assets combined according to predefined rules to create huge numbers of possibilities.

"We have artists who hand-built the rocks, partly from scanning real rocks in our world and changing them," game director Todd Howard said recently. "And then we have algorithms that create the landscape of a planet."

The result is, as I feared, rather like reading the dull, predictable output of ChatGPT. While you can theoretically land anywhere on any planet, in most cases, your choice doesn't matter. When your ship sets down, the game will randomly generate some generic landmarks in the distance, forcing you to trudge along to discover an abandoned military base, or cave, or even an abandoned military base in a cave.

> **"I landed on Venus expecting a toxic hellhole, but found yet another generic rocky planet"**

This is a marked contrast to Bethesda's previous games, which have all felt handcrafted to a much greater extent. With near-infinite "content" to experience, *Starfield* devalues most of it so it feels pointless. Even planets in our solar system suffer from this problem. I landed on Venus, anticipating a toxic hellhole (see page 46), but found yet another generic rocky planet with no signs of the near 500°C temperatures I was expecting. Once I entered the nearby abandoned military base (this one had been overtaken by space pirates!), I laughed upon seeing paper files sitting out in the open atmosphere, with no signs of them spontaneously combusting.

As I continued playing, I learned to avoid engaging with anything that lacked signs of authorial intent, and my experience massively improved. The main story of the game – a galaxy-wide search for mysterious, vision-inducing artefacts – is a standard, if enjoyable, MacGuffin hunt, while the side quests have drawn me deeper into the game's universe. That is before I even mention the ship-building and base-building tools, a seemingly endless crafting system and an extensive skill tree to upgrade. There is a lot worth engaging with here, if you can avoid the boring stuff.

I must admit, with a game this huge, I am yet to come close to the ending, but I can't help feeling that, if you took all the worthwhile quests and locations and cut out all the procedural generation, you would still have enough material to fill an entire solar system. Sure, that's no 1000 planets, but in reality, neither is *Starfield* – it is a bunch of thin encounters, spread even thinner to create a veneer of scale. Once you have pierced that, it is hard to shake the desire for something more substantial. ▮

Events

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SATURDAY 7 OCTOBER

FUTURE STAGE

10:45 - 11:35

ROLLER COASTER VS RIDE SIMULATOR – WHICH IS MOST THRILLING?

BRENDAN WALKER

Thrill Engineer, Thrill Laboratory and Middlesex University

11:55 - 12:45

LIFE IN LILLIPUT – THE MATHEMATICS OF BEING VERY SMALL, OR VERY LARGE

SARAH HART

Mathematician, University of London

13:25 - 14:15

THE FUTURE OF TRANSPORT

SARAH SHARPLES

Chief Scientific Adviser, Department for Transport

14:35 - 15:25

THE FUTURE OF FORENSIC SCIENCE

NIAMH NIC DAEID

Chemist, University of Dundee

15:45 - 16:35

VIRTUAL YOU: HOW BUILDING YOUR DIGITAL TWIN WILL REVOLUTIONIZE MEDICINE AND CHANGE YOUR LIFE

ROGER HIGHFIELD

Science Director, Science Museum Group

MIND & BODY STAGE

10:45 - 11:35

ARE PSYCHEDELICS THE FUTURE OF MENTAL HEALTH?

JONATHAN ILIFF

Neuroscientist and Medical Doctor, University College London

11:55 - 12:45

THE EXPERIENCE MACHINE: HOW OUR MINDS PREDICT AND SHAPE REALITY

ANDY CLARK

Philosopher, University of Sussex

13:25 - 14:15

THE SCIENCE OF KINDNESS

CLAUDIA HAMMOND

Author and broadcaster, BBC

14:35 - 15:25

BEYOND PSYCHOSOMATICS: HOW MIND, BODY AND SOCIETY SHAPE DISABILITY

SUZANNE O'SULLIVAN

Neurologist and author, The National Hospital for Neurology and Neurosurgery

15:45 - 16:35

BI: THE HIDDEN CULTURE, HISTORY AND SCIENCE OF BISEXUALITY

JULIA SHAW

Psychologist and author, University College London

OUR PLANET STAGE

10:45 - 11:35

BLUE MACHINE: HOW THE OCEAN WORKS

HELEN CZERSKI

Physicist and oceanographer, University College London

11:55 - 12:45

THE FUTURE OF MEAT: WHAT WILL WE EAT IN 2033?

TOM MACMILLAN

Professor of Rural Policy & Strategy, Royal Agricultural University

13:25 - 14:15

DEEP OCEAN

LOUISE ALLCOCK

Zoologist, University of Galway

14:35 - 15:25

LIFE BEHIND THE LENS

HAMZA YASSIN

Wildlife cameraman, BBC

15:45 - 16:35

BUSTING MYTHS ABOUT BEING FEMALE

LUCY COOKE

Zoologist, author, television producer and presenter

UNIVERSE STAGE

10:45 - 11:35

METEORITES: THE STONES FROM OUTER SPACE THAT MADE OUR WORLD

TIM GREGORY

Nuclear Chemist and author, National Nuclear Laboratory

11:55 - 12:45

TOWARDS A RATIONAL LIFE: HOW THINKING SCIENTIFICALLY CAN HELP NAVIGATE TODAY'S WORLD

JIM AL-KHALILI

Theoretical Physicist, University of Surrey

13:25 - 14:15

WHEN GALAXIES WERE BORN: FIRST RESULTS FROM THE JAMES WEBB SPACE TELESCOPE

RICHARD ELLIS

Astrophysicist, University College London

14:35 - 15:25

DOWN TO EARTH ASTRONOMY

EMMA CHAPMAN

Physicist, Imperial College London

15:45 - 16:35

THE IRRESISTIBLE ATTRACTION OF GRAVITY: A JOURNEY TO DISCOVER BLACK HOLES

LUCIANO REZZOLLA

Theoretical Astrophysicist, Institute for Theoretical Physics

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New Scientist Live

SUNDAY 8 OCTOBER

FUTURE STAGE

10:45 - 11:35

YOU'VE BEEN PLAYED: HOW GAMIFICATION HAS CONQUERED THE WORLD

ADRIAN HON

CEO, Six to Start

11:55 - 12:45

CYBERSECURILY EVER AFTER: THE CYBERSECURITY OF FAIRY TALES

LUCA VIGANO

Head of the Cybersecurity Group, King's College London

13:25 - 14:15

WHY WE NEED MORE WOMEN IN SCIENCE

ATHENE DONALD

Physicist, University of Cambridge

14:35 - 15:25

THE MILLION-DOLLAR EQUATIONS

TOM CRAWFORD

Mathematician, University of Oxford

15:45 - 16:35

GREAT MOMENTS IN FUTURE SCIENCE

DR KARL

Writer and broadcaster, University of Sydney

Scan me to get
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MIND & BODY STAGE

10:45 - 11:35

A PSYCHOLOGICAL VACCINE AGAINST MISINFORMATION

SANDER VAN DER LINDEN

Psychologist, University of Cambridge

11:55 - 12:45

IT'S TIME TO TALK ABOUT TEENAGE MENTAL HEALTH: UNPACKING THE LATEST SCIENCE BEHIND THE HEADLINES

LUCY FOULKES

Psychologist, University of Oxford

13:25 - 14:15

YOU ARE ELECTRIC: THE NEW SCIENCE OF THE BODY'S ELECTROME

SALLY ADEE

Science and Technology Writer

14:35 - 15:25

ULTRA-PROCESSED PEOPLE

CHRIS VAN TULLEKEN

Doctor and television presenter, BBC

15:45 - 16:35

BUILDING A BRAIN IN A DISH: HOW CAN STEM CELLS HELP US TO UNDERSTAND DEMENTIA?

SELINA WRAY

Senior Research Fellow, Alzheimer's Research UK

OUR PLANET STAGE

10:45 - 11:35

SAVE BRITAIN'S RIVERS!

GRAHAM LAWTON

Feature writer, *New Scientist*

11:55 - 12:45

FIVE TIMES FASTER: RETHINKING THE SCIENCE, ECONOMICS AND DIPLOMACY OF CLIMATE CHANGE

SIMON SHARPE

Director of Economics, UNFCCC Climate Champions

13:25 - 14:15

ANCESTORS: A HISTORY OF BRITAIN THROUGH BURIALS

ALICE ROBERTS

Biological anthropologist, broadcaster and Professor of Public Engagement in Science, University of Birmingham

14:35 15:25

GROWN BY ROBOTS: THE FUTURE OF FOOD PRODUCTION

KIT FRANKLIN

Agricultural Engineer, Harper Adams University

15:45 - 16:35

STAND FOR SOLAR

DANNY KENNEDY

CEO, New Energy Nexus

UNIVERSE STAGE

10:45 - 11:35

JUPITER AND THE JUICE MISSION

MICHELE DOUGHERTY

Physicist, Imperial College London

11:55 - 12:45

THE FUTURE OF MACHINE INTELLIGENCE: FORTUNE-TELLING WITH GENERATIVE AI

MIKE COOK

Senior lecturer, King's College London

AMY SMITH

Artist and PhD Student, Queen Mary University London

13:25 - 14:15

THE SECRET LIVES OF NUMBERS

TIMOTHY REVELL

Deputy US Editor, *New Scientist*

14:35 - 15:25

QUANTUM GRAVITY: THE HARDEST PROBLEM IN PHYSICS?

EUGENE LIM

Professor of Theoretical Physics, King's College London

15:45 - 16:35

LAUNCHING THE UK TO SPACE, FOR GOOD

MELISSA QUINN

General Manager, Slingshot Aerospace

ON THE SHOW FLOOR

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Please note the talks and speakers are subject to change

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NABIL NEZZAR

The dangers of therapy speak

Overusing language once reserved for therapy rooms can do more harm than good, **Lucy Foulkes** tells Catherine de Lange

WHEN Lucy Foulkes was growing up, young people didn't discuss their mental health. Today, things are very different. There are numerous mental health awareness days, the language of psychiatry has become integrated into the vernacular and, in some countries, schools have become the front line in dealing with the mental health issues of young people.

Even so, Foulkes doesn't believe things have necessarily changed for the better. As a psychologist at the University of Oxford, she argues that this societal push to talk about our mental health might not be helping everyone. In fact, it could be making things worse. She talks to *New Scientist* about how "concept creep" and "therapy speak" are doing people a disservice when it comes to mental health.

Catherine de Lange: It feels like there is a mental health awareness campaign almost every week. Surely that is a good thing?

Lucy Foulkes: It seems like it is, but I think there are all sorts of reasons why it might not be. These campaigns are often designed for social media, posters, billboards or whatever, so they are necessarily very shallow when, actually, mental health is an incredibly complex topic. They tell people to go and get help, and the help often isn't there. A lot of campaigns are encouraging people to talk and not enough are teaching people to listen.

The big thing that I'm really interested in is whether they encourage people to interpret essentially all negative thoughts and feelings as symptomatic of a disorder or a problem. ›

Mind and Body Stage
Hear more from Lucy Foulkes at New Scientist Live
newscientist.com/nslmag

PETER TITMUSS/ALAMY

Schools are now on the front line of mental health, but aren't well equipped to take on that role

That has big consequences in terms of making people feel unnecessarily vulnerable and viewing themselves as having a disorder when they don't. Partly tied up with this, I think when everyone uses this language, it means the people who really do have the most serious mental health problems are even less acknowledged than they were before. The language is being taken away from them.

What sort of language are people using inappropriately?

I saw a TikTok video the other day, and it said: "If you're wondering if you've had trauma, here is the test: are you hurting? If you're hurting, then you're experiencing trauma." That is just so far removed from what trauma was originally supposed to mean.

There has been a general trend in the past 10, 20 or 30 years to view our experience through the psychiatric lens. We're looking for everything to have a psychological name. But there has also been a more recent discussion about "therapy speak" – that everything is being seen through the lens of language that was once reserved for the therapy room.

Nick Haslam [at the University of Melbourne, Australia] talks about concept creep and he argues that, over the past 30 years or so, terms relating to harm – like "bullying", "trauma", "mental illness" – have become expanded and expanded, so that more and more mild experiences fall under this language. He argues that we are increasingly seeing harm everywhere – and seeing ourselves as being vulnerable to harm. In some respects that's a good thing as plenty of people have been abused and bullied and experienced trauma, and that hasn't been recognised. But there's a side that is now being misapplied. The end result is that you feel weak and vulnerable in a way that isn't useful.

Is therapy speak also having a detrimental effect on society? For example, the actor Jonah Hill was criticised recently for using the concept of "personal boundaries" as a way to control someone else's behaviour.

I guess it's a problem when it's used the way Jonah Hill was said to have used it – under the guise of self-care to manipulate and control someone else in an inappropriate way. You could argue that this whole thing is just neutral – observe it as a kind of cultural shift. But I think it's a problem when it makes everyone feel more vulnerable, because a lot of this language is the language of vulnerability and victimhood and harm.

Surely for some people it is useful to put a label on things?

Definitely. It's very validating. It helps you understand yourself. It helps you communicate your distress to other people and it might potentially be a ticket to getting help, particularly in schools. So, in some respects, these labels are very helpful. But in other respects they can make people believe they have a problem that they don't really have.

There have been several studies in schools showing that teaching young people about mental health can make them feel worse. They end up reporting more symptoms than people who never had these lessons. I'm trying to bring together all this research, and also conduct more of this work myself. It's actually not a new idea. For a long time, people have mused over how the way you label things can affect how you experience something. This is the concept of the "sick role": how you change once you've adopted a diagnosis.

OLIVIASPRINTEMPORIUM/ETSY

For some people, it is useful to put a label on their mental health issues

What research are you doing to explore this?

It's basically about trying to test the hypothesis that mental health awareness efforts are contributing to the increase in reported rates of mental health issues that we're seeing. Part of that is theoretical work and bringing together the evidence. Then a new strand that I'm setting up is trying to see whether you can experimentally manipulate the information you show people or tell them and see whether you can temporarily induce more or less reporting of anxiety, for example. There's some evidence you can do that with blood pressure: if you tell people they're above average, it affects what they subsequently report. If you can show that's happening with mental health in a lab setting, that would be quite a powerful argument that it's potentially happening on a bigger scale in society.

You have also been working in schools in the UK. What is the situation there?

In the past, schools didn't consider people's psychological well-being or mental health, or the impact that education might have on it. But in recent years, there's been a shift and school is seen as a place where these things should be spotted and managed. Unfortunately, a lot of this falls on teachers, who aren't necessarily

trained to do it or want to do it.

I worked on a big mindfulness trial that was about training school teachers to be mindfulness teachers and teaching children either eight or 10 weeks of mindfulness lessons – and whether that would improve their mental health. It didn't. For that and for various other projects, I have spoken to a lot of schools and they're desperate for mental health support. They want to know what their role should be. There's such a climate of fear around it that they are tending to treat everything as a mental health problem that they can't touch, when actually, old-fashioned social support might be really powerful. But I don't blame them. I think they're in a really difficult position because they're receiving all these messages about a mental health crisis, like everyone else.

How might this kind of over-psychiatrising in schools lead to further problems?
Anxiety is a really good example. An increasing number of young people are saying that they don't want to do something on the grounds of anxiety. I get a lot of emails from teachers about this – and the same thing is happening in universities with undergraduate students. Sometimes the most appropriate response is to make an adjustment for that person. They shouldn't be asked questions in class or they shouldn't have to sit exams in a big hall, for example. But this genuine, useful principle has been blown out of proportion. It seems like in some cases in schools, people are automatically being given an adjustment – they are told they don't need to do something – with no intention to ever review it.

The trouble is that the worst thing you can do in terms of maintaining anxiety in the long run is allowing people to not do the thing that scares them. Actually, the most useful therapeutic thing is to support them, step by step, to do what they are scared of. If, with support, you gradually do the things that make you anxious, you learn two things. One is that it isn't as bad as you thought it would be, and the other is that, even if it is bad, you cope. If you avoid things, you never get the opportunity to discover this so you just remain perpetually anxious.

> "A lot of this language is the language of vulnerability and victimhood and harm"

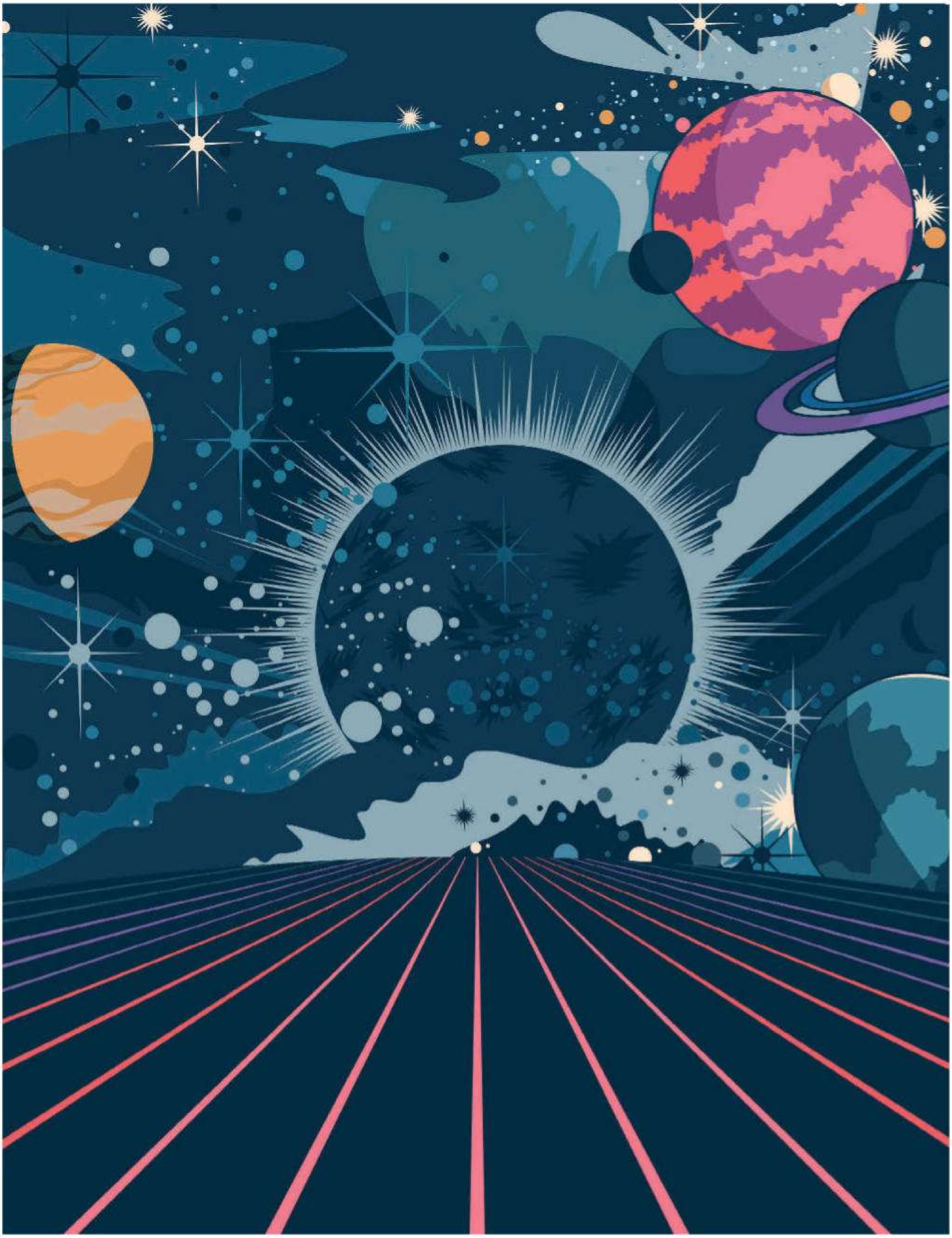
It sounds like what's going on in schools isn't working. What should we do differently?
Something needs to change. I don't yet know what the answer is. I feel like I'm at the very beginning of trying to press pause on what's happening and understanding what might be going wrong. There's so much fear at the moment. No one wants to miss something, so everyone is being treated as a sort of potential risk. There's also a kind of risk of liability on the individual teacher and on the school. So I think there needs to be better understanding of who are the young people who really do need one-to-one support and who can be supported just by teachers being helpful, trusted adults. But both of those things cost money and might involve training.

The reason teachers are often in such a bind is that there's a big chunk of children who aren't unwell enough for a referral to CAMHS [Child and Adolescent Mental Health Services, provided by the National Health Service (NHS)] but that do need more help than teachers have been trained to offer. There are various initiatives trying to tackle that – including something called mental health support teams that are being set up in schools in England [in conjunction with the NHS] – but they all seem to be doing something slightly different. They are currently being rolled out across the country. But it's early days and we've not yet got data on how much they're improving things.

I've heard you jokingly compare some of your views to those of the controversial commentator Piers Morgan. How have people responded to your work?
I disagree with Piers's approach – I'm definitely not calling all young people snowflakes. I think multiple things can be true at once, so I think talking about mental health is really good for some people and possibly problematic for others. I also always try to take the approach that this isn't young people's fault.

I've generally had a lot of support, a lot of people saying they agree but they didn't want to say this themselves. So I think there is an appetite for this argument to be made – just not many people actually want to be the one that's making it. ■

Catherine de Lange is magazine editor at *New Scientist*



CECILIE AND GILLES

Out of the shadows

A bizarre new class of star powered by dark matter could solve a supermassive mystery in cosmology. Have we already spotted some, asks **Jonathan O'Callaghan**

IN THE early days – and we are talking very early, not long after the big bang – the universe might have been littered with strange stellar monsters. Wide enough to engulf our whole solar system, these stars would be powered not by nuclear fusion, like a regular star, but instead by dark matter: specifically, particles of this mysterious stuff self-annihilating to fuel so-called "dark stars".

That is the idea, at least. But when Katherine Freese, a theoretical astrophysicist at the University of Texas at Austin, first presented it at a conference in 2007, it didn't go down particularly well. "I overheard some graduate students calling us crackpots," she says.

Regardless, the concept of dark stars has stuck with Freese. Over the past 16 years, she and her colleagues have refined their understanding of these tantalising hypothetical objects. The problem was, finding evidence for them always seemed out of reach.

Until recently, that is, because Freese and hercolleagues have reported a potential sighting: unusual galaxies seen by a new telescope. "Maybe some of these objects aren't really galaxies at all, but actually singular stars – dark stars," says team member Jillian Paulin, then at Colgate University in New York.

Echoes of doubt still sound among other astronomers. "It's a very controversial idea," says Cosmin Ilie, also at Colgate University, who led the team. But if they do exist, dark stars would not only be evidence for a specific kind of dark matter. They could also help crack one of the biggest problems in cosmology – the mysterious origins of the supermassive black holes that drive galactic evolution.

Our universe is awash with dark matter. We can't see it directly, because it doesn't interact with light, but we know it is there. It reveals itself by warping space-time, producing a lensing effect that distorts our view of other objects that we can see. "We have tons of evidence about the gravitational nature of dark matter," says Pearl Sandick at the University of Utah. "It exists, and we know where it is."

It is through these observations that we know dark matter ought to compose some 27 per cent of the universe. Around 68 per cent is the equally inexplicable dark energy that drives the universe's expansion, with a mere 5 per cent being the normal matter that makes up chairs, tables and people.

Violent annihilation

We don't know precisely what dark matter is, although we have some ideas. In the late 20th century, a candidate called a weakly interacting massive particle, or WIMP, was introduced. Up to 1000 times more massive than protons, WIMPs wouldn't interact with regular matter. But they would affect each other – and violently. Two such particles would annihilate on contact, producing a burst of energy in the form of gamma rays.

We can also infer how dark matter would have behaved in the early universe. After the big bang, around 13.8 billion years ago, the universe was filled with a morass of particles, with no complex structures. Dark matter moves more slowly than normal matter, so would have clumped together more easily under gravity. In the first 200 million years of cosmic history, huge conglomerations of dark matter called mini-halos formed. Eventually, these sucked in regular matter too, which formed stars and galaxies.

Freese's realisation was that if these mini-halos were full of WIMPs, it could have led to an interesting process akin to the creation of a normal star. "We realised we had this process that the astronomy community had missed," she says. It was an entirely new kind of star.

Stars form when a collapsing cloud of dust and gas made of regular matter condenses. Gravity squashes hydrogen and helium atoms together, eventually reaching the threshold at which nuclear fusion begins and the core of a star is forged. In stars, the force of gravity pushing inwards is exactly balanced by the force outwards from fusion.

But if the density of dark matter were high enough in some halos, annihilating WIMPs might produce enough energy that the outward force would prevent normal matter reaching the critical density. Nuclear fusion would never start – instead, you would have a different class of object that would stabilise at a far greater size, perhaps with a diameter similar to that of Saturn's orbit and a mass up to a million times that of the sun. "There's this heat source which prevents that cloud from collapsing any more," says Freese. "They're powered by dark matter."

The dark matter content of the stars would be low, just 0.1 per cent. But that would be enough to produce trillions upon trillions of annihilations per second, making the star shine incredibly brightly in brilliant white or blue. In that sense, "dark star" is a misnomer. In the most extreme cases, dark stars could grow truly gigantic and outshine even entire ›

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galaxies in the early universe. "They can get a billion times as bright as the sun," says Freese.

Freese published a series of papers on dark stars, the first of which, written with her colleagues Douglas Spolyar and Paolo Gondolo, appeared in 2008. Dan Hooper at the University of Chicago remembers there was "intense debate" when they were published. "I would go to talks and hear people yell at each other," he says. "I didn't know who was right and wrong."

The idea has some support. "I think it's a very cool idea that's absolutely possible," says Sandick. It is also far from the only exotic star that has been proposed (see "The strangest stars", left).

There is good reason to hope that these theoretical stars do exist. Aside from being an entirely new kind of star, dark stars could offer a solution to a big cosmological mystery: the origin of supermassive black holes. These are the monster black holes, so dense that even light can't escape them, that sit at the centre of galaxies.

When we look at the distant, early universe, we see galaxies younger than a billion years old with supermassive black holes that are a billion times the mass of our sun at their centres. How these black holes grew so quickly is a puzzle. "The emergence of such massive black holes in the very early universe is a big problem," says Muhammad Latif at the United Arab Emirates University. They may have grown from merging smaller black holes, but there doesn't appear to have been enough time for that to happen.

Dark stars could be the answer, in that they could be the elusive seeds of supermassive black holes. They would mostly have lived fast and died young, lasting only millions of years. Smaller dark stars, perhaps 100 times or so the mass of our sun, might be reborn as regular stars once WIMP annihilation ceased. "Once their dark matter fuel runs out, then fusion might kick in," says Freese.

But all dark stars, once they ran out of fuel entirely, would collapse into black holes. In the case of supermassive dark stars, given their huge masses, the resultant black holes would be equally massive, up to a million solar masses. "We actually solve the outstanding big black hole problem," says Freese. "If you start with our dark stars, you'll have million-solar-mass seeds that could merge together to make billion-solar-mass black holes."

THE STRANGEST STARS

Dark stars (see main story) are far from the only exotic stellar phenomena we may or may not ultimately discover in space.

JANUS STARS

In July, astronomers said they had spotted a star that was apparently split down the middle, with one half made of helium and the other made of hydrogen. It had two faces, like the god Janus in Roman mythology. It now seems this star may have just been caught at a strange moment, right in the middle of transitioning from burning helium to hydrogen, a process many white dwarf stars are thought to go through.

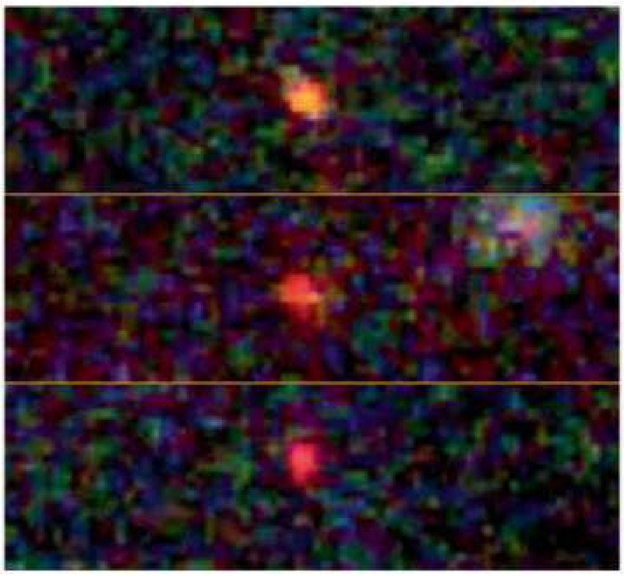
HYBRID STARS

Also known as Thorne-Żytkow objects, these consist of a neutron star within a regular one. They are the Russian dolls of stars, if you will. They probably form when two stars collide and merge. During their short lives, they would look indistinguishable from other large stars. These remain hypothetical – the only way to discover one would be through a combination of gravitational wave measurements and observations of the elements within the star.

BOSON STARS

When is a black hole not a black hole? When it is a boson star. Stars are normally made of fermions, the particles that make up matter. But it is possible for bosons, the force-carrying particles of nature, to cram together in almost unlimited numbers and create a transparent object that does little except exert a huge gravitational pull on everything around it. These objects would be almost indistinguishable from black holes – which is why astronomers haven't yet devised any easy ways of finding them.

> "Dark stars can get a billion times as bright as the sun"



NASA/ESA

Distant smudges seen by JWST could be exotic dark stars

During the 2010s, however, the case for dark stars hit a snag. Other candidates for dark matter emerged and the case for WIMPs weakened. With no evidence for WIMPs, lighter theoretical particles called axions became many physicists' bet for explaining dark matter. And axions would be too light to produce enough energy to form dark stars. Others, like Bernard Carr at Queen Mary University of London, favour the idea that dark matter isn't made of mysterious particles at all, but consists of black holes created in the early universe, called primordial black holes.

Yet Freese remained bullish about the prospects of dark stars, and now things are looking up. In 2022, she and her colleagues calculated that other dark matter candidate particles could form dark stars. "It doesn't have to be WIMPs," she says. There is an alternative where dark matter is still envisaged as a particle, but one that interacts more strongly with itself. This self-interacting dark matter concept is popular at the moment, says Freese.

Then, earlier this year, the furthest-seeing eye in the sky spotted something.

Red smudges

The James Webb Space Telescope (JWST), launched in December 2021, is able to peer back deep into the universe's history thanks to its large gold-plated mirror that observes in infrared light. It has already seen galaxies dating to the first few hundred million years of the universe, earlier than any galaxies seen by any other telescope. Those results have shown more bright objects in the early universe than expected. "There's no doubt that the results of JWST do indicate that something strange is going on," says Carr. Galaxies weren't expected to grow much until a billion years or so after the big bang, but JWST seems to have found lots of galaxies forming much earlier.

In June, astronomers on the JWST Advanced Deep Extragalactic Survey (JADES) announced a handful of new candidate galaxies that were the earliest yet, with one dating to just 320 million years after the big bang. Freese and her colleagues, however, put out a pre-print paper – a study yet to be peer-reviewed – suggesting that these might not be galaxies. Instead, they think the objects, appearing as red smudges to JWST, are individual dark stars.

Their reasoning is that three of the objects appear rounded, like a star, and lack the wispy features of a galaxy. The objects also fit the model of dark stars, with the amount of light produced consistent with what would be expected. Two of the candidates are estimated at a million times our sun's mass, and one of them at half that.

It is still possible that these will turn out to be very small galaxies, perhaps appearing like individual point sources because of a lack of resolution. "We still prefer the simpler solution," says Sandro Tacchella at the University of Cambridge, who is part of the JADES team. "At the moment, there is no clear evidence for a dark star model." Marcia Rieke at the University of Arizona, also part of the JADES team, is similarly cautious, noting that two of the three candidates did appear to have wispy features consistent with a small galaxy, while the third could simply be a compact galaxy. "To claim something is a dark star, you really need to have pretty solid proof," she says.

There is a chance we might get it. In October, JADES will gather the second half of its data, including detailed spectra of these objects, which means measuring the light they emit across a range of wavelengths. We should be able to pick up the signature of an ionised form of helium, known as helium-II. If the mystery objects are dark stars, astronomers would expect to see the helium-II absorbing light at a specific wavelength. If, on the other hand, they are galaxies, they would expect helium-II to emit light at that wavelength. "The smoking gun signature of a dark star is the helium-II feature," says Paulin.

There may be more dark star candidates, too. Ilie says he is working on a new paper with fresh sightings from JWST observations. "We're not going to be lacking candidates," he says. Only JWST has the power to find dark stars at the moment, although the likes of NASA's upcoming Roman Space Telescope, set to launch in 2027, might also have what it takes.

For the majority of astronomers, the idea of dark stars remains hard to swallow. "Most people prefer to be conservative and not invoke some weird thing like dark stars," says Carr. But then again, our cosmos is littered with unlikely objects, from black holes to magnetars. "We're surrounded by weirdness," says Carr. Why not dark stars, too? ∎

Jonathan O'Callaghan is a freelance writer based in the UK

History, decoded

Cracking secret messages from centuries past is painstaking work. But linguists and computer scientists are starting to automate the process, with some sensational results.
Joshua Howgego reports

VATICAN APOSTOLIC ARCHIVE

The Vatican's archives contain thousands of manuscripts that are encrypted

BEATA MEGYESI strode past the Pontifical Swiss Guards, in their Renaissance-era uniforms. She was headed not for the Sistine Chapel or St Peter's Basilica, but the Vatican's archives. Precious few people are allowed into this legendary collection of documents and letters spanning 12 centuries. Yet even in that context, Megyesi's 2012 visit was unusually intriguing. She was here to see texts so secret that no living person, not even the pope, could tell you what they contain.

Megyesi, a linguist based at Uppsala University in Sweden at the time, had travelled to the Vatican to pore over a tranche of papers written in elaborate ciphers – the secret codes used by spymasters and others eager to send private messages. An expert in cracking historical codes, she had been invited after breaking the notorious Copiale cipher.

Megyesi had the opportunity to use the Vatican's encrypted papers for a project with an audacious goal: to fully automate the process of decrypting historical ciphers so that many thousands of otherwise inaccessible letters could finally speak to us from down the centuries. "The dream is to be able to point your phone camera at a cipher and read it immediately," she says.

In the decade since, Megyesi and her colleagues have developed software that expedites their painstaking cryptanalysis – and researchers associated with the project have notched some remarkable successes. These include the recent decryption of a particularly fiendish code employed by a 17th-century French nobleman and, most sensationally, the cipher encrypting letters written by Mary, Queen of Scots, during her imprisonment at the hands of Queen Elizabeth I.

Breaking historical ciphers is difficult because they can work in so many different ways. A useful place to start is to assume that whatever cipher you are confronted with contains homophones, or symbols that represent one sound or letter of the hidden message. In a very simple cipher, for example, every "a" in the original message – which is known as plaintext – could be replaced with a "b", every "b" with "c" and so on. Cryptanalysts would try many combinations of substitutions until they start to get a message where a few fragments of words begin to make sense.

But unless your cipher is very basic, it won't stop there. Many historical ciphers also contain elements called nomenclators, symbols that represent syllables, whole common words or names. These can be extremely hard to crack unless you have some sense of what the letter is about or who wrote it and can make an educated guess about what the nomenclators mean. Sometimes, these symbols can even be "nulls" – characters that have no meaning and should be discounted – just to throw adversaries off the scent.

Over the centuries, expert cipher creators developed ever-more sophisticated techniques. For example, not all codes are homophonic. Polyphonic ciphers sneakily use the same individual symbol to refer to more than one letter or sound and are harder to crack. Then there are ciphers that involve translations of letters, for example swapping the first and last letters of every word before you can read the plaintext. There is even super encryption, when plaintext is encrypted and then the encrypted version is encrypted again using a second cipher.

Take the Copiale cipher, the code encrypting text inside a 105-page manuscript bound with green and gold brocade-backed paper, thought to date from around 1750 and discovered in an academic archive. Its name derives from one of just a few words written in plaintext. The rest of it is a bizarre mix of familiar-looking Roman letters and obscure symbols. It is obviously a code, and the expensive feel of the manuscript makes it seem as if it mattered to someone. But who wrote it, and what does it say?

Solving the riddle

Megyesi, now at Stockholm University in Sweden, began work on this cipher in 2011 with her colleagues Christiane Schaefer at Uppsala University and computer scientist Kevin Knight at the University of Southern California. The first step was to devise a way of making the code machine-readable, which they managed by effectively encoding it so that each symbol was assigned a letter on a keyboard. They could then carry out a frequency analysis, to see how often each symbol was used and to look for statistical patterns. For example, the most commonly used letters in modern English are, roughly speaking, e, a, r, i and so on – so by working out the frequency of symbols, you can often guess what they mean. ›

Cybersecurely ever after
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After a few dead ends, the team arrived at two key hypotheses: that the underlying text was written in German and that each unaccented Roman letter marked the start of a new word, while the more obscure symbols encoded letters. With these potential breakthroughs in hand, they could use a computer algorithm to try out a range of cipher keys until they alighted on the correct one and had figured out the homophones. With that, the code was broken.

The Copiale cipher turned out to have been written earlier than thought, in the 1730s, by a secret society known as the oculists operating in what is now Germany. It contained details of a bizarre initiation ritual that involved, among other things, new members being asked to read a blank piece of paper and having a single hair plucked from their eyebrow. (The oculists used sight as a metaphor for knowledge.)

Following this success, Megyesi began thinking about how cryptanalysis could be automated to make some of the most laborious aspects of the process less so. Advances in artificial intelligence were coming on apace, which suggested that computers could do much of the work. Rather than digitising the code symbols manually, perhaps computer vision AI could be used to recognise and sort them. It might also be possible to develop software to run frequency analysis and decipher most of the homophones. It would be a difficult undertaking to develop each of these tools and stitch them together into a seamless process. But it would be worth it if it allowed us to enter a vast, hidden world of historical secrets. Crucially, Megyesi would need a large collection of encrypted texts to use as a training ground.

That was what took her to the Vatican. Once inside the archives, she ordered up boxes of documents and went through them by hand, identifying those written in ciphers. "I thought back to when they would have been written; the candles, the quills," she says. In the end, she selected thousands of examples and the Vatican provided digital copies of them.

Automated decryption

With that treasure trove in hand, in 2015, Megyesi gathered a small team and founded what would go on to become the DECRYPT project to work on the documents and start trying to automate the decryption process. The first challenge was to develop an algorithm that cracks the homophones of a cipher by trying lots of different possibilities. In itself that wasn't enough to completely automate the decipherment, but it did speed up the process. With several researchers on board to use it, the team was soon cracking dozens of ciphers every year.

The bulk of the documents from the Vatican turned out to be letters from nuncios, or papal ambassadors stationed in foreign countries. Spanning the 15th to 17th centuries, most were anything but sensational – generally they contained everyday gossip and requests for people to be paid. But when you are decrypting lots of documents, sooner or later you are bound to come across something explosive. And that is precisely what happened when another of the project's researchers got his hands on an intriguing cipher held in France.

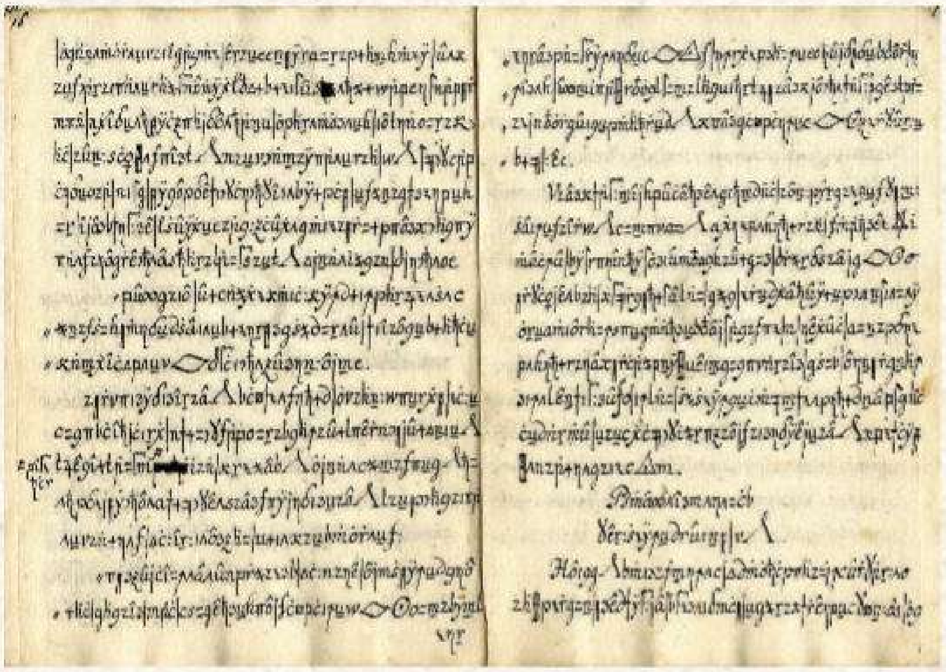
George Lasry is a computer scientist at Google in Tel Aviv, Israel. Around a decade ago, he began playing around with cracking ciphers, inspired by a blog on which readers were challenged to break the ones posted there. Eventually he got so good that he is now part of the DECRYPT project.

As well as working on the ciphers from the Vatican, Lasry would also check a website called Cryptiana maintained by Japanese physicist Satoshi Tomokiyo. In his spare time, Tomokiyo waded through the archives of national libraries and when he discovered historical ciphers, he would post them on the "unsolved" section of his site. In March 2021, noticing that Tomokiyo had posted an encrypted document called BNF fr.2988, which he had discovered in the collection of the National Library of France in Paris, Lasry began to study it. "It was just another puzzle," he says. At least, that was how it seemed.

Once Lasry had discerned that the underlying plaintext was in a historical form of French, he applied his own cryptanalysis program to work out the homophones with relative ease. But this only revealed a small part of the message. The cipher used a series of "diacritics", or symbols with dots next to them that modify what they represent, and a particularly sprawling series of nomenclators to symbolise names and common endings of French words, including "-ent", "-oit" and "-endre".

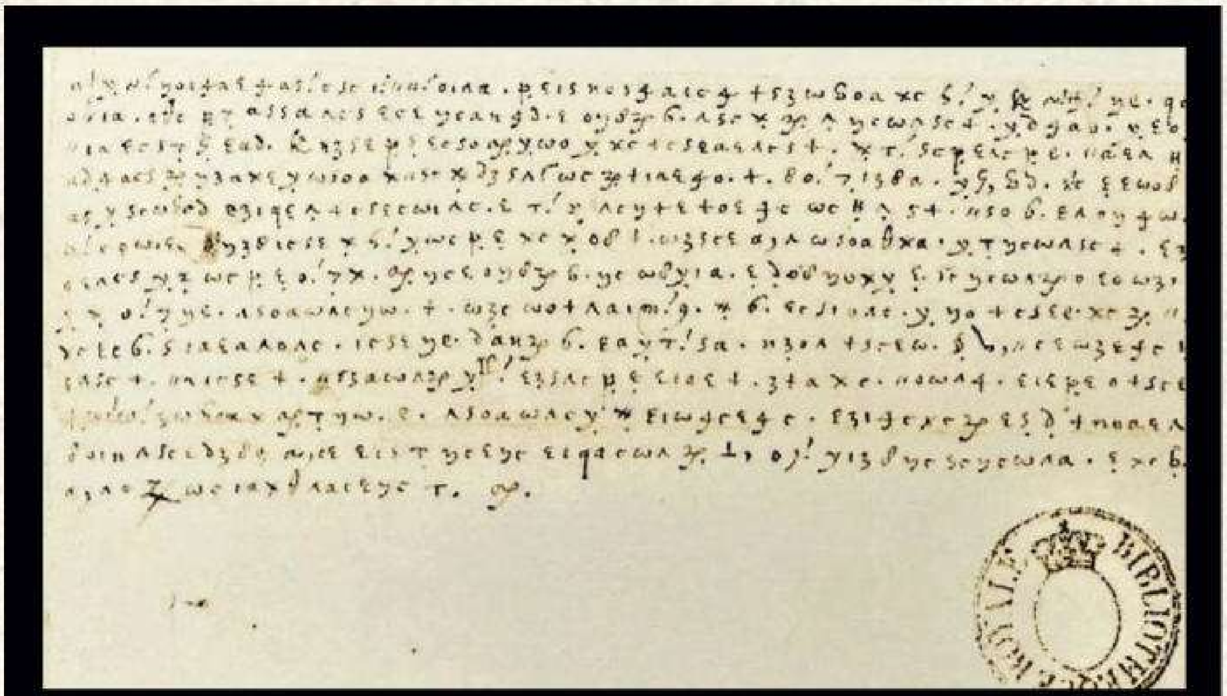
With many of the symbols defeating him, Lasry recruited his friend Norbert Biermann, at Berlin University of the Arts in Germany, to help. Biermann was a major asset, and not only because he is an expert cryptanalyst. He also happens to be a professional pianist and helps produce operas, some of which are written in Middle French, the language of the text. Working together, Lasry, Biermann and Tomokiyo gradually figured it out. One of the last pieces of the puzzle slotted into place when Biermann realised that a certain symbol meant "delete previous", a particularly confusing trick.

The document wasn't signed or addressed, but from the content the trio could deduce that



KEVIN KNIGHT, BEÁTA MEGYESI, CHRISTIANE SCHAEFER

The Copiale cipher, written in the 1730s by a secret society operating in what is now Germany



A sample of ciphers used in the letters sent by the imprisoned Mary, Queen of Scots (portrayed left)

PAINTING/ALAMY; KEVIN KNIGHT, BEÁTA MEGYESI, CHRISTIANE SCHAEFER

> “For historical significance, the decoding of Mary’s letters is hard to beat”

it was a letter written by a woman imprisoned in England with a son. The other big clue was that it also mentioned Francis Walsingham, Queen Elizabeth I’s spymaster. From all this, they came to their breathtaking conclusion in February this year: the letter must have been written by Mary Stuart, otherwise known as Mary, Queen of Scots. The documents Tomokiyo had discovered turned out to contain 57 letters, written between 1578 and 1584, and Lasry and Biermann went on to decipher them all.

Stunning find

The decryption made headlines around the world. Mary had a disputed claim to the English throne, which made her politically dangerous. As a result, she was caught in a web of 16th-century plotting and spent many years imprisoned. Historian John Guy at the University of Cambridge has called the work “stunning” and “the most important new find on Mary Stuart, Queen of Scots, for 100 years”. The reason for his excitement is that, now we know what they say, we can see that the letters offer fresh insights into how Mary negotiated regarding her and her son’s future with her contacts in France and Elizabeth I’s court.

For historical significance, the decoding of the letters of Mary, Queen of Scots, is hard to beat. Even so, when many of the world’s best historical codebreakers gathered at the HistoCrypt conference in Munich, Germany, in June, they were buzzing with talk of other scintillating successes.

For instance, Cécile Pierrot at the French National Institute for Computer Science Research in Nancy had heard a rumour about a mysterious letter stored somewhere in the city. Word on the grapevine said it was a missive from Charles V, the Holy Roman Emperor for most of the first half of the 16th century. Many academics knew the story, she says, but there were no details about the letter’s location.

Pierrot asked everyone she could think of and, after two years of searching, found the letter at Nancy’s library. It identified Charles V as the sender in plaintext, so it was obviously the real deal. Pierrot and her colleagues cracked the cipher in late 2022. It turned out to be a communication to Jean de Saint-Mauris, one of the emperor’s ambassadors. Among other things, it mentions a rumour of an assassination plot, giving historians an insight into Charles V’s fears at the time.

Lasry also revealed another remarkable result at the conference. It concerns a letter written by a French nobleman called Armand de Bourbon, a leader in a series of civil wars in 17th-century France known as The Fronde. Lasry showed that Bourbon used a cipher that is neither polyphonic nor homophonic, but polyhomophonic – in other words, some of its individual cipher symbols can represent several plaintext letters, but equally each plaintext letter can be represented by several different cipher symbols. Lasry says that, to his knowledge, it is the only cipher of this kind discovered so far.

How close are we to having an app that automatically decrypts historical ciphers? The DECRYPT project now has a piece of software called CrypTool 2, created by Nils Kopal at the University of Siegen in Germany. If you feed cipher symbols into it, the program can do an automated cryptanalysis to find the homophones and often partially breaks the code. As things stand, the team has cracked more than 2500 ciphers, most of which were aided by its algorithms.

What has proved much more challenging is the first step in the process: having computer vision AI recognise and digitise enciphered texts. Alicia Fornés at the Autonomous University of Barcelona in Spain has been leading on this part of the project. She and her team have tested various AI models for the task, but it has proved extremely difficult to train them, because the handwriting from these letters written centuries ago is so variable. The other problem is that the symbols often touch each other, such that computers struggle to discern where one ends and another begins. The team has recently had more success by hand-labelling the symbols and using these datasets to train algorithms – but it remains tricky.

For her part, Megyesi is actually in no rush to get to the stage where you can point a smartphone at a historical cipher and read it instantly. That might well be the stated goal of the project, in her own words. “But frankly, it would be a bit sad to have an app that does this,” she says. “Because who doesn’t want to have the enjoyment of cracking codes?” ▮

Joshua Howgego is a features editor at *New Scientist*

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Mathematics of life

Slice, slice, baby

You ordered a pizza for your party, but the restaurant forgot to slice it – these tricks can help you cut it evenly, says **Katie Steckles**

Katie Steckles is a mathematician, lecturer, YouTuber and author based in Manchester, UK. Follow her @stecks

FAIRNESS is important – in life, and in pizza. If you want to cut a pizza into equal-sized pieces, the difficulty will depend on how many people you need to share it between. Luckily, mathematics has some tricks to keep things equal.

For example, if the number of people you are sharing a pizza between is a power of two – one, two, four, eight, 16 – cutting the pizza into as many slices is easy. For one piece, obviously no cuts are needed. For each larger power of two, a cut across through the centre of the pizza – cutting all of the existing pieces exactly in half – will result in pieces of equal size.

Some numbers will be much harder: prime numbers, by definition, can't be divided easily. Luckily, geometry can help.

If you need to cut a pizza into five equal pieces, first grab a long, thin, rectangular strip of paper. Tie the paper in an ordinary overhand knot, like you would tie in a piece of string. Then, keeping the ends flat, pull gently to tighten the knot. The whole thing will flatten and come together – stop pulling when you can't go any further without it wrinkling.

The flat shape you are looking at should now be vaguely familiar, if you ignore the two ends of paper sticking out. Fold these ends into the middle, or cut them off, and you will have a shape with five straight edges, created purely by the shape of the knot. Yes, that is right – you have made a perfect regular pentagon, with five equal-length sides and five equal angles at the corners.

MALKOVSTOCK/ISTOCKPHOTO/GETTY IMAGES

It is possible to prove this mathematically by showing that all the folds you make in the paper strip are at 72 degrees to the parallel edges of the strip. But for simplicity, because the paper is the same width everywhere, and weaves in and out five times in the right way, these will be five equal edges. And more importantly, the pentagon's corners are equally spread around a circle – making it the perfect guide for pizza slicing.

Place your pentagon in the centre of the pizza, then cut along lines radiating out from the centre of the pentagon and through each corner. And presto: you have a pentagonal pizza party for five. This paper-strip method can be used whenever you are in a pentagon-based emergency.

You can use the same technique to produce a shape with any odd number of sides by creating a more complex knot with the strip passing through the middle more times, although the strip of paper needs to be increasingly thin and it takes a lot more patience to pull the ends through and carefully flatten out the shape.

Combined with our existing halving methods, you can now produce any number of slices you like. The same results can be extended to any other round food – thanks to maths, the world is your cheesecake.

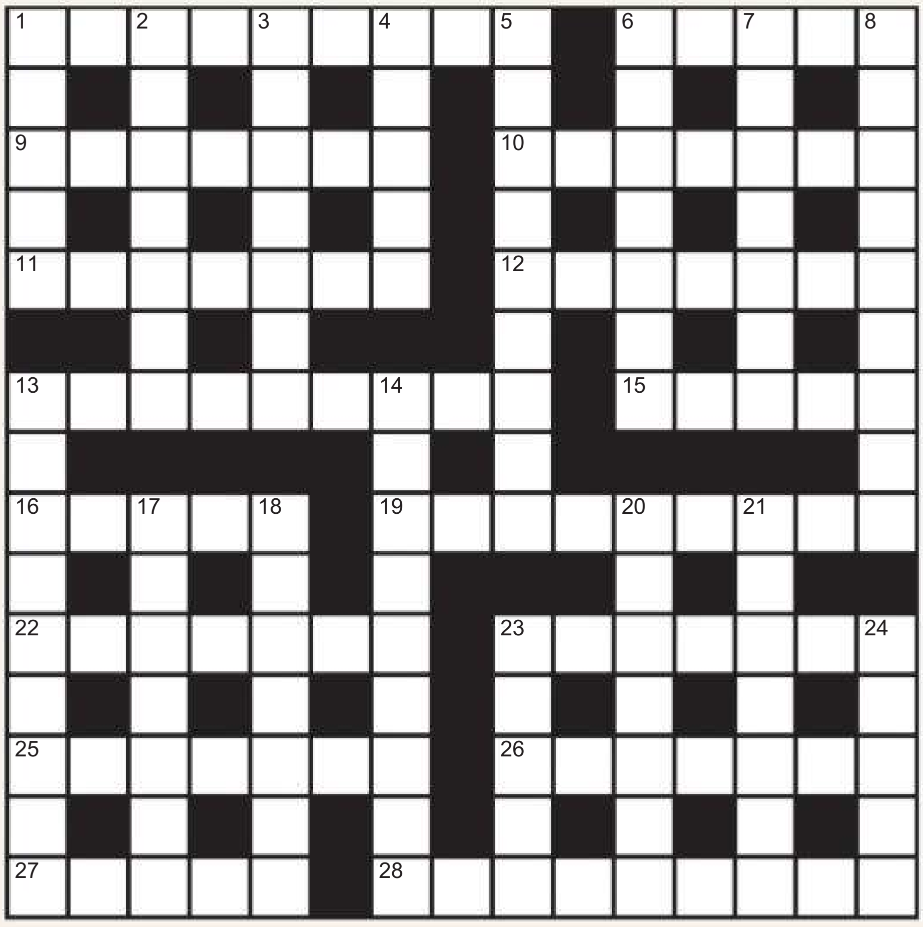
See Katie slice her pizza fairly at youtube.com/newscientist

These articles are posted each week at newscientist.com/maker

Mathematics of life reveals the mathematical ideas and shortcuts behind everyday situations

Next week
Debunking gardening myths

Quick crossword #142 *Set by Richard Smyth*



Scribble zone

Answers and the next cryptic crossword next week

ACROSS
1 First chompers? (4,5)
6 Circulating bodily fluid (5)
9 ___ psychology, 20th-century theory of perception (7)
10 Logically self-contradictory statement (7)
11 Less old (7)
12 Orifice; vent (7)
13 Lubricating tool (6,3)
15 Alien enemy of Dan Dare (5)
16 Halved (2,3)
19 Immediately after childbirth (9)
22 A property of a thermodynamic system (7)
23 Incorporate; absorb (7)
25 Sugar pill, perhaps (7)
26 No less than (2,5)
27 Dweeby; nerdy (5)
28 Typeface developed in 1957 (9)

DOWN
1 Prone to glitches (5)
2 Counterbalanced structure such as a lever (7)
3 Xylyl bromide or capsicum spray, perhaps (4,3)
4 Write (in a form); go in (5)
5 Ball-and-socket structures at the top of femurs (3,6)
6 Least small (7)
7 Childbirth specialist (7)
8 Six-sided (9)
13 Experimental subject, figuratively (6,3)
14 Ketch built for Sir Francis Chichester (5,4)
17 To determine the concentration of a solution (7)
18 The formation of mountains (7)
20 Clouds of star-forming dust (7)
21 Tidal wave (7)
23 Not big (5)
24 Additional (5)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #220

set by Bethan Ackerley

1 The surgical joining of two organisms is known as what?

2 Which of the following alloys doesn't contain copper: pewter, tombac or Wood's metal?

3 Phycology is the study of what?

4 Name the ancient Greek polymath credited as the first person to calculate the circumference of Earth.

5 In what year was Dolly the sheep born?

Answers on page 47

Headscratcher

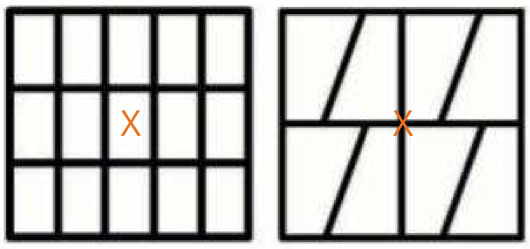
set by Colin Wright

#240 Tango tiles

The new Astoria Hotel has a square ballroom with a chandelier hanging directly over the centre of it. There is one job remaining – to tile the floor.

The owner, Lord Fusspot, has three demands. First, the tiles must all be congruent (which means they are all of the same shape, but can be rotated and/or flipped). Second, for some superstitious reason, the edge or corner of a tile can't be directly underneath the chandelier. Third, there must be an even number of tiles.

Not too unreasonable, is it? And yet this turns out to be a fiendishly difficult puzzle. For example, the tiling on the left would be fine except that it has an odd number of tiles, while the one on the right has an edge under the chandelier (which is marked as X).



If you can find a way to do it, give yourself a medal. If you can do it with fewer than 10 tiles, make that a gold medal.

Solution next week

Hot property

Would it be theoretically possible to build a large habitable dome on the surface of Venus, one of the most inhospitable places in the solar system?

Mark Thompson
Tewkesbury, Gloucestershire, UK

Good luck! Venus has the densest terrestrial atmosphere in the solar system, at around 93 times thicker than Earth's.

To put this into context, imagine having 93 kilograms resting on 1 square centimetre of your body. It would be like having a giant panda sitting with all its weight on your little toe. So, you would need a method of moving from your spacecraft to the dome, because, when standing on the surface of Venus, you would be crushed by the sheer mass of all the atmosphere on top of you.

Your next problem is that the thick Venusian atmosphere is composed mainly of carbon dioxide, which is a greenhouse gas. So, when the sun's light heats the planet, the warmth can't efficiently radiate back into space because it is trapped by the CO_2. This heats the planet up dramatically. On the surface of Venus, temperatures can reach around 460°C, making it the hottest planet in the solar system.

> **"On the surface of Venus, temperatures can reach around 460°C, making it the hottest planet in the solar system"**

Hillary Shaw
Newport, Shropshire, UK

The two biggest problems with living on Venus might be your source of power and your water supply.

We could probably design and maybe even build a dome there that could resist the horrendous conditions of 93 bar pressure, 467°C temperature and sulphuric acid rain. We would even have a possible oxygen supply because the Venusian atmosphere is 96 per cent CO_2, the rest being mainly nitrogen and a dash of sulphur dioxide.

However, you then need a power source to turn the CO_2 into oxygen and, crucially, to cool your dome, and there is very little water there. That means not much hydrogen, which could be used as a fuel.

Worse, the quantity of solar radiation reaching the surface of the planet is just 25 watts per square metre, well below Earth's of around 342 watts per square metre. It is hard to see what other energy sources are readily available to human colonisers on the Venusian surface.

Venus is likely to have volcanism, but this energy may be hard to harness. You almost have the basic ingredients of plant fertiliser – from the elements nitrogen, sulphur, carbon, oxygen and maybe phosphorus – present on the Venusian surface, but not in anything like a form we could use as fertiliser, without an energy source to convert them.

Also, Venus's surface gravity is similar to that on Earth and to get back home, you would be going up the sun's "gravity gradient" (or on a long, roundabout gravitational slingshot journey). It is a one-way journey for the robots we send.

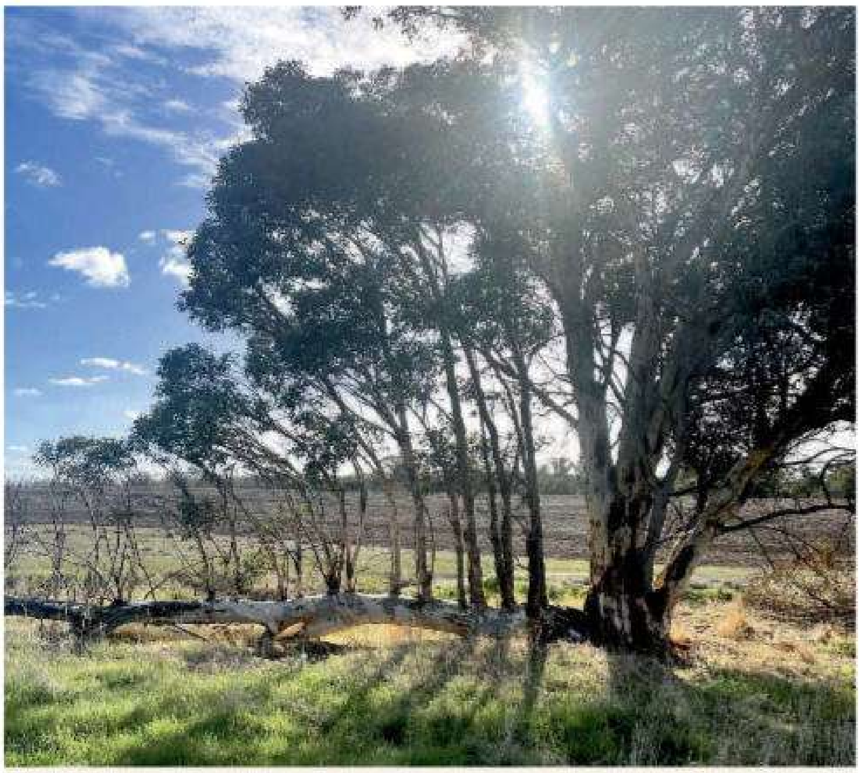
David Bortin
Whittier, California, US

I can say with complete confidence that it isn't "theoretically possible to build a large habitable dome on the surface of Venus", since no one in my lifetime has any chance of doing it. But simply as a question of theoretical engineering and technological feasibility, I can't say "never".

Baby steps have already been taken: in 1985, an uncrewed Soviet probe survived on the surface of Venus for almost an hour. In the US, NASA's DAVINCI mission is on the agenda for a 2029 launch to orbit Venus, sniff around and case the joint for a couple of years, then ultimately deploy a surface probe.

What convinces me of the idea's theoretical impossibility isn't just the "how on Venus?" question, but also the one about "why on Venus?". Justification through return on investment calculations is a necessary first step to selling any major project to sources of financing. Investment includes exporting all materials, supplies and consumables (including water) from Earth to Venus, as well as volunteers recruited for a one-way trip to hell.

Payoff includes: the ability to study close up the consequences of climate change and a runaway greenhouse effect (which, if there are any questions left to be answered, could be better addressed by remote devices less combustible than human bodies); the "because it's there" human mindset that drives people to climb Mount Everest or to swim from Cuba to Florida; and, finally, the satisfaction of proving me wrong.


ANNA BUTCHER

Why is this fallen tree growing new branches from its horizontal trunk?

This week's new questions

Gum up **Why and how do fallen trees, such as this white gum from Western Australia, grow stems vertically from a horizontal trunk? *Anna Butcher*,** *Brookton, Western Australia*

High speed **We know time slows down as gravity increases, so is the speed of light in high gravity different from its speed in low gravity? *Simon Walker*,** *Melbourne, Australia*

On a roll

When a round coin rolls down a slope, it stays upright, so why does a "square" coin sliding down a slippery slope soon fall over?

Ron Dippold
San Diego, California, US

The round coin has two related advantages, rotational inertia and being a mini gyroscope.

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Tom Gauld
for New Scientist

Let us take the square coin first. If it is sliding down a slippery slope, narrow side leading, there is little to prevent it from tipping over. It is sitting on a narrow edge on a slippery surface, so it is inherently unstable. All it takes is the slightest variation in the slope to make it fall over. Basically, there is no reason for it to stay upright – falling over is just as good as going forwards.

Now, consider the round coin. It is a freestanding wheel. Once it picks up speed, it has rotational inertia, and an object "wants" to keep travelling in the direction it is currently heading unless there is an outside force like friction (Isaac Newton's first law of motion). Even if your slope flattens out, the coin will keep rolling quite a way until friction brings it to a stop.

Second, it is now a gyroscope. Any spinning wheel resists rotating in any axis other than the one it is already turning in (Newton's first law again!). The easiest way to feel this yourself is with a detached front bike wheel or by using some wood or a box to raise the front wheel of a bicycle off the ground. Try turning the wheel left and right, then get the wheel spinning as fast as you can with your hand. Now try turning the wheel left or right again. You will feel the gyroscopic force of the wheel resisting you because you aren't turning it in the direction of the rotational inertia.

> **"Get on a non-moving bicycle and, with your feet off the ground, try to stay upright. Pretty dang hard, right? This is your square coin"**

This is used as a stabiliser in many applications, such as with film cameras. So, the rotating coin actively resists turning left to right (turning) or top to bottom (falling over), and it "wants" to keep rolling. It is a rolling machine! The only way it will fall over is if the slope is so uneven that the coin is stopped or tilted too far to recover.

Again, we can use the bicycle as an example. Get on a non-moving bicycle and, with your feet off the ground, try to stay upright. Pretty dang hard, right? I can't do it. This is your square coin. But as soon as the bicycle is rolling just a few kilometres per hour, staying upright is trivial. Your coin is one of the wheels, rollin', rollin', rollin' (Rawhide!)

Guy Cox
Sydney, Australia
When you spin a top, it stays up, but once it stops, it falls over. That is the gyroscopic effect: rotating objects resist changing their angle of rotation because it changes their angular momentum. Gyroscopes are used in all sorts of things, from Segway scooters to navigation systems.

In the case of your coin, so long as it is rotating, it will stay upright. But there is nothing to keep your square coin upright, so over it goes.

David Haller
Via Facebook
Let me put away my frisbee and yo-yo, hop on my bike and head on over to answer the question.

Answers

Quick quiz #220
Answers

1 Parabiosis
2 Wood's metal (this contains bismuth, lead, tin and cadmium)
3 Algae
4 Eratosthenes
5 1996

Cryptic crossword #118 *Answers*

ACROSS 1 Annulus, **5** Paris, **8** Vacuum cleaner, **9** Lee, **10** Non-random, **12** Pernio, **13** Spasms, **15** Epicentre, **16** Ant, **18** Metal detector, **20** EPROM, **21** Mitosis

DOWN 1 Anvil, **2** Nuclear winter, **3** Loud noise, **4** Second, **5** Pie, **6** René Descartes, **7** Shrimps, **11** At present, **12** Preemie, **14** Stream, **17** Torus, **19** Lem

#239 Snap judgement
Solution

It will always require 14 snaps. You start with one piece, and each snap creates one additional piece. The double-width chunk doesn't affect the answer.

Twisteddoodles *for New Scientist*

THE NEXT IG NOBEL PRIZE GOES TO SOME WONDERFUL RESEARCH...
...OUTSTANDING IN BOTH ITS UNUSUAL NATURE AND UNEXPECTED RESULTS.
MAY THIS PRIZE BE A SOURCE OF PRIDE TO THE LAB
AND MAY THE FUNDING BODY HAVE A SENSE OF HUMOUR ABOUT IT.
@twisteddoodles

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Consideration of items sent in the post will be delayed

September is here, and with it the year's new crop of 10 Ig Nobel prizes, each for a piece of research chosen with the same simple criterion – that it makes people laugh, then think. As per tradition, Feedback presents them to you.

A question of taste

Jan Zalasiewicz at the University of Leicester, UK, won the chemistry and geology Ig for explaining why many scientists like to lick rocks. His essay "Eating fossils", in The Palaeontological Association's newsletter, emphasises the simple practical gain: "Wetting the surface allows fossil and mineral textures to stand out sharply, rather than being lost in the blur of intersecting micro-reflections and micro-refractions that come out of a dry surface." During the ceremony, he acknowledged that, yes, sometimes it is also a matter of taste.

A team based in France, the UK, Malaysia and Finland won the literature prize "for studying the sensations people feel when they repeat a single word many, many, many, many, many, many, many times". Their paper, called "The the the induction of *jamais vu* in the laboratory: Word alienation and semantic satiation", was published in the journal *Memory*.

During the ceremony, Nobel laureates present Ig Nobel prizes to the winners. Nobellian Al Roth told the team: "I have to say, I had never seen a paper like this before, and I say congratulations and congratulations and congratulations and congratulations."

Spidery grip

Te Faye Yap, Daniel Preston and their colleagues at Rice University in Texas won the mechanical engineering prize for reanimating dead spiders to use as mechanical gripping tools, thus pioneering a field for which they invented the name: "necrobotics".

In presenting them the prize, Barry Sharpless, who has two Nobel prizes in chemistry, confessed he himself is terrified of spiders because of a childhood encounter with tarantulas. He expressed admiration for the necroboticists' courage.

Seung-min Park won the public health prize for inventing the Stanford Toilet, a device that uses a variety of technologies – including a computer-vision system for defecation analysis and an anal-print sensor paired with an identification camera – to monitor and quickly analyse the substances that humans excrete. During the ceremony, Park spoke of his mixed hope and dread in trying to simultaneously diagnose individual people's health problems and protect their privacy (and privates).

Going backwards

María José Torres-Prioris, Adolfo García and their team won the communication prize for studying the mental activities of people who are expert at speaking backwards. Their study "Neurocognitive signatures of phonemic sequencing in expert backward speakers" focused on a community in La Laguna, Spain, where some people grow up learning to speak backwards as well as forwards.

The medicine prize went to Natasha Mesinkovska and her team at the University of California, Irvine, for using cadavers as a means to explore whether there is an equal number of hairs in each of a person's two nostrils. Their surprisingly charming write-up in the *International Journal of Dermatology* says that the average nose hair count per nostril is around 120 in the cadavers they examined. This started out as an attempt to learn the medical significance, if any, of there being hairs in one nostril but not the other in a living individual with alopecia.

It's electrifying

Experiments to determine how electrified chopsticks and drinking straws can change the taste of food won the nutrition prize for Homei Miyashita and Hiromi Nakamura at Meiji University in Japan. They have found ways, they report, to make food taste saltier than it really is. This is a potential health boon for people who like to dine on food that gains its tastiness from being ultra-salty.

Katy Tam, Christian Chan and their colleagues won the education prize for methodically studying the boredom of teachers and students. Anyone with sufficient interest can read details of that research in a pair of studies: "Boredom begets boredom: An experience sampling study on the impact of teacher boredom on student boredom and motivation" and "Whatever will bore, will bore: The mere anticipation of boredom exacerbates its occurrence in lectures".

In 1969, Stanley Milgram – famous for his series of experiments about "obedience to authority", in which people seemed to obey instructions to give electric shocks to strangers – performed a more gentle experiment.

Milgram (who died in 1984) and two of his students – at least one of whom, Leonard Bickman, is still alive – were awarded the psychology prize for experiments on a New York City street to see how many passers-by stopped to look upward when they saw strangers looking upward. Bickman accepted the prize on behalf of the entire trio.

Bieito Fernández Castro and his team won the physics prize for measuring the extent to which ocean-water mixing is affected by the sexual activity of anchovies.

The entire Ig Nobel ceremony was again, as in the first three pandemic years, held online. ■

Marc Abrahams

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